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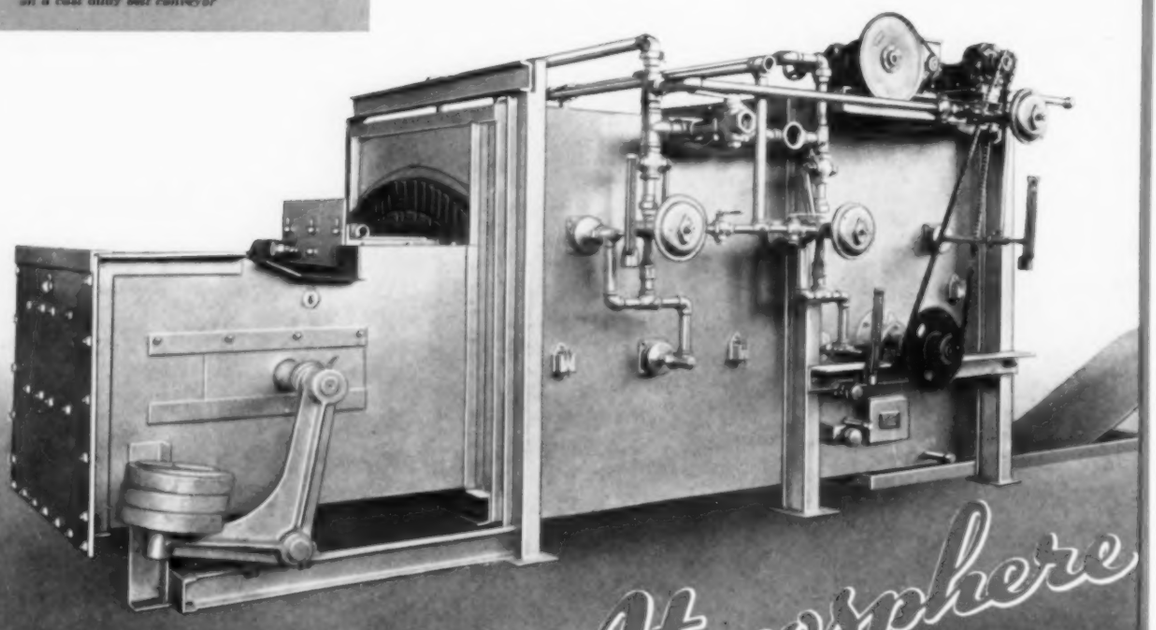
1933

METAL PROGRESS

This continuous clean hardening furnace is one of several similar SC units recently installed. This furnace is a muffle type unit with atmosphere surrounding the work which is mechanically passed through the furnace on a cast alloy belt conveyor



Controlled Atmosphere Furnaces

Controlled Atmosphere Furnaces are being used for bright annealing of ferrous and non-ferrous metals—for clean hardening, nitriding, and gas carburizing of steel. SC Furnaces for each of these processes are available for continuous or batch operation. All of these processes have been pioneered, developed and made commercially practical by SC Engineers. These same engineers will be glad to go over details with you, pertaining to your problems. Perhaps the solution may involve the application of only minor equipment.

● SC Continuous and batch type controlled atmosphere furnaces for bright annealing of ferrous and non-ferrous metals, for clean hardening, gas carburizing, nitriding, forging of steel, all are playing a very important part in today's heat treatment of metals.

Many SC furnaces have been recently purchased for these heat treating processes. Each installation contributes to an already generous experience with Controlled Atmosphere furnaces, gained since the original development of these processes by SC engineers.

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Surface Combustion Corporation

TOLEDO, OHIO

Sales and Engineering Service in Principal Cities

METAL PROGRESS

Vol. 24 *December, 1933* *No. 6*

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The leading article in this issue is the first of a series by Mr. Kinkead, a Cleveland engineer long on the staff of Lincoln Electric Co., but more recently established as a successful consultant on welding problems. The articles will summarize lectures he is now giving before the Cleveland Chapter.

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American Society for Steel Treating

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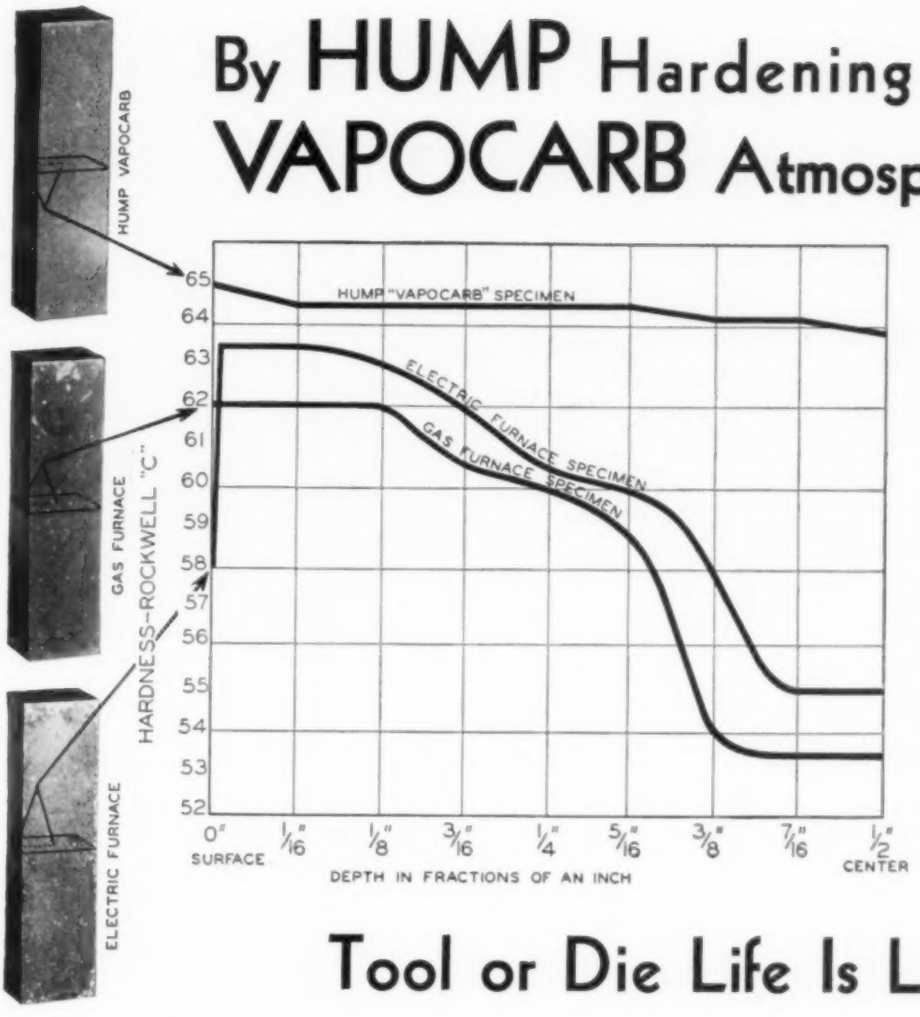

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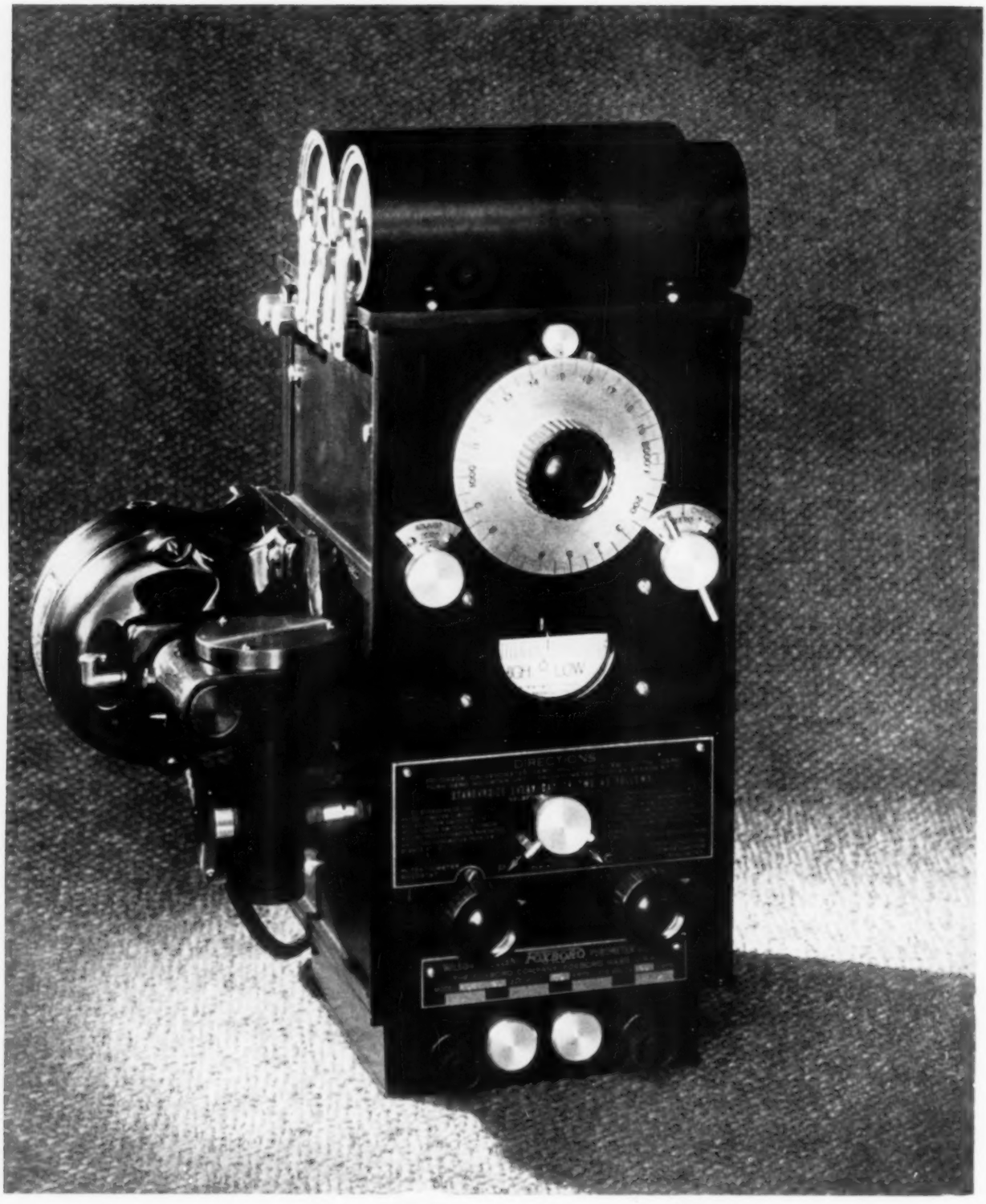

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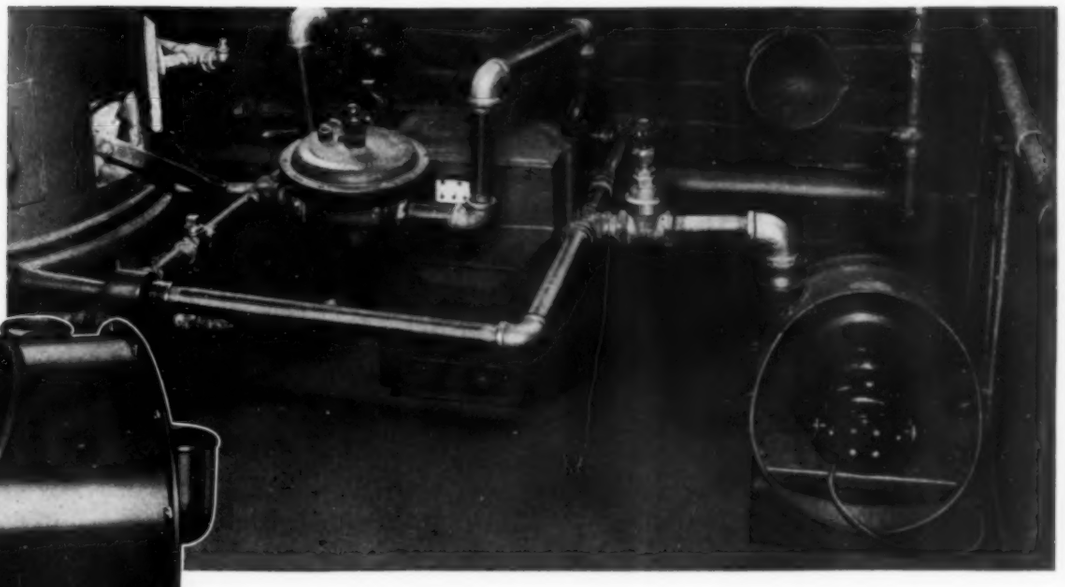

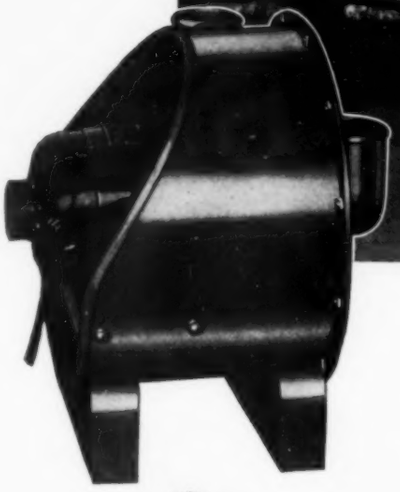

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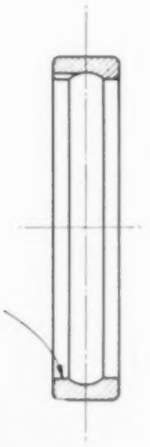

How Test for Hardness ?

IT depends a lot how far in you must do your testing to give you the information you need. It depends a lot, too, on the simplicity or complexity of shape to be tested, for it is essential to have good firm anvil support.

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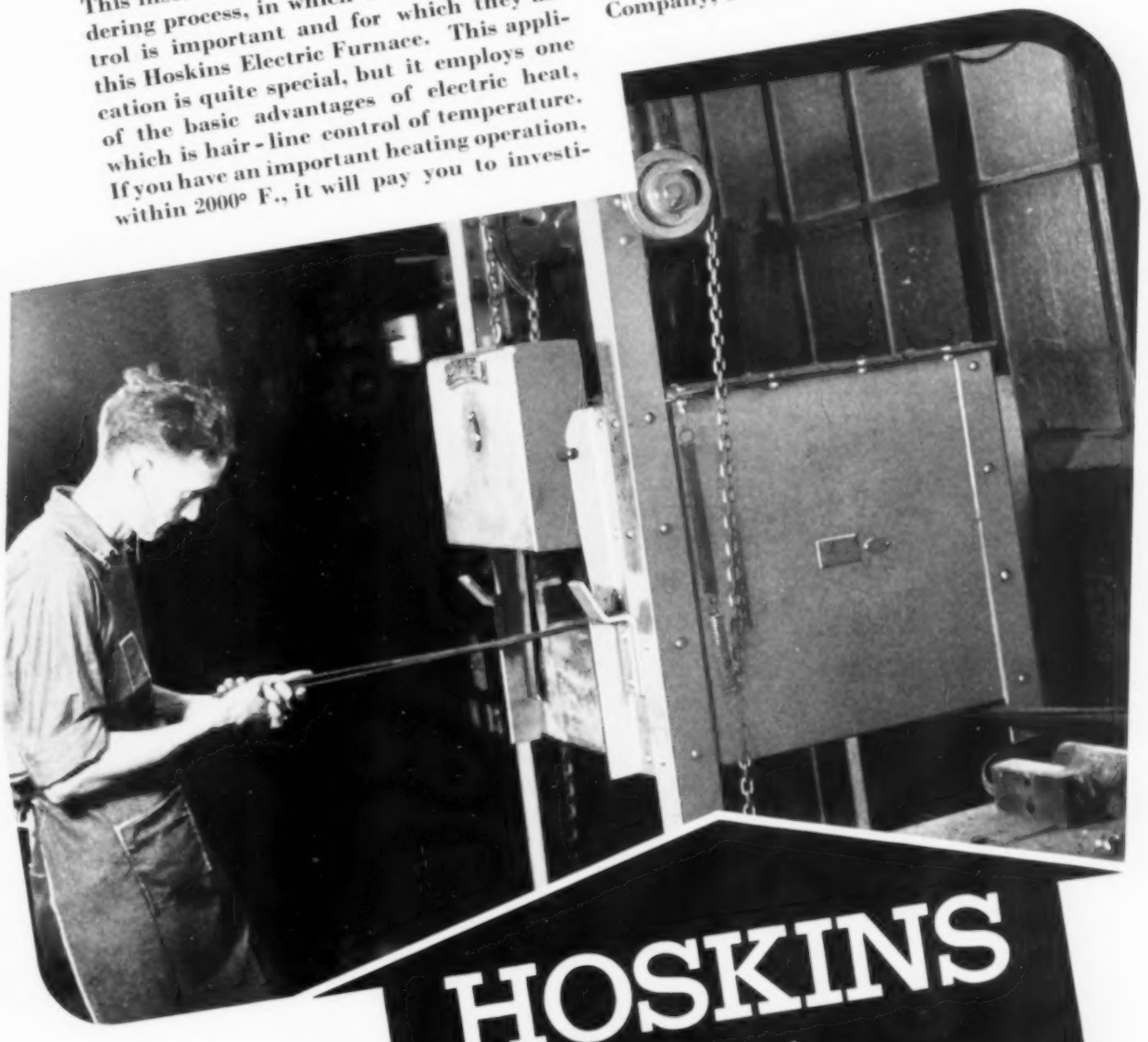

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A Resolution for 1934

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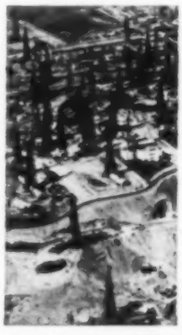

Time was when no one could tell just how long a machine would last. The buyer installed it and *hoped* for the best. But that was before alloys containing Nickel introduced a new degree of dependability.

Now, thanks to Nickel, alloys of increased dependability are being produced which amazingly add to the life and efficiency of machinery, saving the basic industries millions of dollars every year.

It is rare today to find any type of truly modern equipment that does not contain some moving or highly-stressed parts made of some alloys containing Nickel. For, when correctly alloyed with other metals, Nickel

produces a wide range of improved properties that makes these alloys more highly resistant to heat, stress, fatigue, abrasion, corrosion and wear.

Tons and tons of these versatile alloys—Nickel Alloy Steels, Nickel Cast Irons, Nickel Bronzes, Stainless Steels, etc.—are used every year in the basic industries. They are used in the construction of

crushers, drills, power shovels, grinding mills, rolling mills, hoists, mine cars and locomotives, trucks and tractors; in pumps, bearings, gears, shafting, valve and pressure castings and in scores of other applications where greater endurance, increased efficiency and low cost operation and maintenance invariably result. When you consider all the advantages of alloying with Nickel, the extra cost is really small in relation to the benefits secured. In many cases only a little Nickel (from ½% to 5%) is required to produce definitely superior mechanical properties.

Moreover, these alloys containing Nickel are commercially available in all important metal consuming centers *in a variety of compositions*, each carefully established by exhaustive laboratory tests and field service. If you are planning to build new equipment or modernize the old, they will help you to suit it better to modern operating conditions.

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(A NICKEL CAST IRON)

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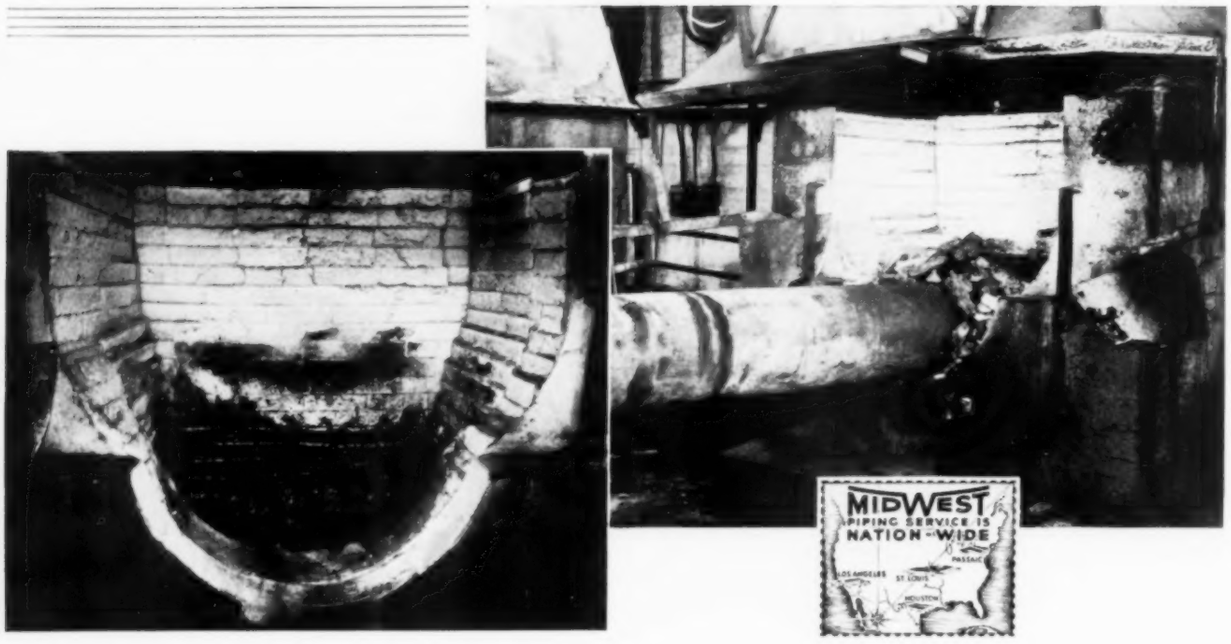

Still another application proves the Economy of CARBOFRAX

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AT the Ballwood Division of the Midwest Piping and Supply Company Inc., they use coke-fired furnaces for heating large pipe and flanges to a welding temperature. Ordinary fire clay brick in the fuel zone lasted but a week even with daily patching.

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They get cleaner welds with "Carbofrax" linings—there is a distinct saving in brick costs—in longer continued furnace operation—in labor costs.

Just another case where "Carbofrax" proves its economy.

Where higher first costs are not to be considered when the service rendered more than justifies it.

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● Note the difference in growth and scaling between protecting tubes of 15 per cent chromium cast iron and one of ordinary white or hard iron. (A) A new tube of 15 per cent chrome cast iron. The sharp letters show the fluidity of the metal. (B) A similar tube after several months service at temperatures up to 1800 deg. F. (C) A hard-iron casting, made from the same pattern and subjected to the same service as the center tube. Note the extreme growth and scaling.

HIGH CHROMIUM CAST IRON

FOR installations at elevated temperatures, High Chromium Cast Irons are rapidly replacing ordinary gray iron and white iron castings because they resist heat, oxidation and abrasion, and are free from growth. One recent report states that after more than a year's continuous service, 14 per cent chrome stoker links "showed absolutely no signs of wear or corrosion and were in as perfect condition as when installed".

Containing from 12 to 30 per cent chromium—the amount depends on service requirements—these alloy irons are free from growth at temperatures up to 1800 deg. F. and are protected against oxidation by the formation of a thin, very adherent scale. Their higher physical properties further adapt them to severe conditions of heat, oxidation and abrasion.

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An Arc Welder Making Arc Welders

Courtesy Lincoln Electric Co.

Suitability of welding depends on the importance of the joint to the integrity of the structure, the ability to match the composition of the metal to be joined, the damage to the latter done by the necessary heat, and the chance that this may be corrected.

An Engineering Appraisal of the Welding Processes

WELDING is a process which numberless people have used, yet the true nature of a weld is still something of a mystery. Hence "weld" is difficult to define except by citing illustrations.

Welds are ordinarily made with the help of heat. The limiting case would be two pieces of metal, melted in separate crucibles and poured together into a mold. This would certainly constitute a weld — in fact, it is a true "autogenous" weld. The best illustration is the thermit process of welding, where highly superheated steel is poured between the preheated surfaces to be joined, but the oxy-acetylene, arc welding, and atomic hydrogen processes also operate in essentially the same way.

While heat is an essential for making a weld, complete fusion is not necessary to weld some metals. The common example is blacksmith welding of wrought iron. He uses borax to flux the scale on the hot surfaces, and relies upon pressure of hammering to squeeze out this slag. This process introduces pressure as well as heat. In other varieties of welding the pressure required for welding increases rapidly as the heat is lowered, for the essence of the process is to bring the clean, highly active metal surfaces into intimate contact — even atom to atom.

Another necessary condition is that the surface of the weld be not a plane surface but a region of inter-penetrating crystals. It follows that welds made by pressure without heat (as wringing together of optical flats) would be unsatisfactory because they have no strength in shear.

Even if the above paragraphs cannot be regarded as a definition of welding, they give the basis for a classification of the modern welding processes, each of which produces heat in a manner adaptable to the job in hand. Broadly they comprise (*a*) processes which operate by heat alone (that is, actual melting) and (*b*) those which produce pressure as well as heat.

In the first group is *thermit*, which uses liquid steel at 4000° F., more or less. Next may be mentioned the *carbon arc* and the *metallic arc* process, both very efficient methods for melting and superheating metal up to its boiling point (the limiting temperature). *Atomic hydrogen* and *oxy-acetylene* welding are alike in that they produce sufficiently high temperatures by a gas flame which is of a reducing nature, and therefore automatically protect the hot reactive metal from the atmospheric gases oxygen and nitrogen (a most important matter which must be taken care of in the arc process by supplementary fluxes, electrode coverings, or gas envelopes). The latest process may be

By Robert E. Kinkead
Consulting Engineer: Welding
Cleveland, Ohio

called *hydrogen electric* welding. It really is copper-brazing in a hydrogen atmosphere at a temperature only slightly above the melting point of copper — the hydrogen, like a flux, cleans the steel surfaces, and the copper melts and runs into all crevices and between abutting joints. It was described in METAL PROGRESS by C. L. West last July.

The second main subdivision of the modern processes — those requiring both heat and pressure, like the old forge or hammer welding — includes varieties of *resistance* welding. After the resistance welding machine has been equipped with proper grips and timing devices, it is a rapid and convenient device for applying heat and pressure, and promotes sound welds every time. Depending on the extent of the heated region, the process is subdivided as (*a*) butt, (*b*) seam and (*c*) spot welding, terms which are well known and self-explanatory. As the time allotted for the generation of heat is progressively diminished, we have (*d*) flash, (*e*) shot and (*f*) electro-percussive welding.

Flash welding has been used for sheet metal work — principally auto bodies — and is fairly well known. *"Shot-welds"* are made in small fractions of a second, to limit the heat effect to sub-surface regions — an important point on heat treated or cold worked sheet. It was also described by E. J. W. Ragsdale in METAL PROGRESS last July. *Electro-percussive* is little known outside the electrical industry. It is used to butt-weld wires of various sorts; a condenser discharges across the closing gap between wire-ends, forming an explosive arc which liquefies instantaneously the very surfaces. Most of this liquid metal seems to be blown off, so the weld is made by impact at sub-melting temperatures and the heat effect is highly restricted.

Trouble Comes From Heat

It is safe to say that all the processes mentioned give a minimum of grief as far as the equipment is concerned, or the technique of the process. Practically all the trouble that is experienced comes when you apply intense heat, locally, to cold metal. It is well to examine carefully into this problem, for the work, such as autogenous welding of flange steel or structural steel, is indeed a brutal operation. Pieces to be welded when coming from the blacksmith's forge, may be heated to incandescence at one end, but the heat tapers back gradually, even to the end of the bar, which may be several feet away. In the modern processes the entire cycle of heating to melting, and then quenching in the cold surrounding metal, occurs rapidly and may extend no further back than a fraction of the way to the edge. The complex stresses and strains which this sets up in the welded parts will be the subject of a later article.

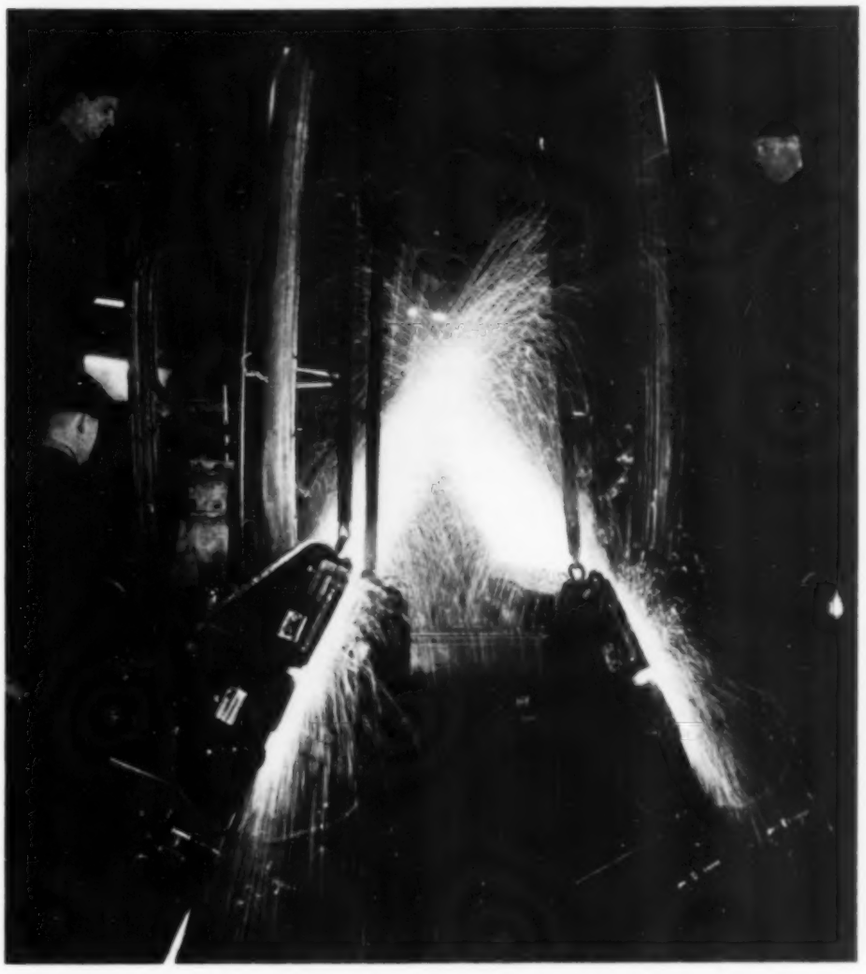
For the present let us consider what happens to the metal, as such, at the very joint. What can be expected of it? Engineers select a certain metal for a certain service on account of definite physical or mechanical characteristics which make it likely that it will perform successfully. For instance, metal with a high endurance limit would be preferred for high speed turbines; metal able to transmit heat readily would be selected for gas engine heads; metal with great toughness for field artillery; corrosion resistant metal for chemical equipment; strong and ductile metal for boilers, bridges, and buildings. It is obvious that successful welding should change these valuable properties for which a metal is selected as little as possible.

These properties are conferred on commercial metals by the process of manufacture; intrinsically they are due to the chemical composition of the alloy, and are enhanced by properly changing the microstructure by subsequent processing, such as hot work on the ingot, cold work on the semi-finished material, or heat treatment of the completed part. It follows, therefore, that metal in the welded joint should have exactly the same composition as the base metal (or one which is intrinsically better fitted for the service intended) and that the operation should derange the previous microstructure to a negligible extent. If the last cannot be guaranteed, there is a possibility that the weld metal and its environs may receive some hot work, cold work, or heat treatment which will restore the original desired microstructure.

Let us appraise the various processes on that basis:

The arc process does greatest violence to the metal, because of the intense local temperatures and the steep temperature gradient back

into the base metal. There is no chance to hot work this metal at the joint — time is too short before it cools off. Some cold work is ordinarily done on the deposited metal with a peening hammer, to remove slag, relieve shrinkage strains, and prepare the way for grain refinement by the heat of successive layers on multi-run joints.



Fire Works When Large Flash Welders Join Back Panel of Dodge Car to Two Upstanding Side Panels to Form a Mono-Piece Steel Body

But at the very joint it must be apparent that the properties conferred on the base metal by previous hot or cold work or heat treatment have been entirely obliterated. Certain undesirable and quite complicated internal stresses have been introduced (as indeed they are in all types of welding). The chemical composition is altered — at least slightly. It results that the ductility, the relationship of yield point to ultimate strength, the malleability, and toughness of an important portion of metal in the structure have all been altered somewhat.

Whether or not these changes are too serious to be endured, whether they can be mitigated by proper welding technique or subsequent treatments, or whether they are of little or no consequence to the design or structure in hand, is a nice problem in engineering.

The oxy-acetylene and atomic hydrogen flame does less violence to the metal than the electric arc. There is more control of the temperature, as the operator can back the flame away from the work, or play it about. The process is somewhat more deliberate, hence much heat is drawn away from the joint; it is therefore distributed through a larger volume and has a lower gradient. (This is not an unmixed blessing, for it increases the danger of warpage in broad surfaces or long pieces by releasing internal strains already existing in the metal, as well as by introducing new ones in different places.) There is an opportunity for some hot work on the weld metal, although it is not done nearly as frequently as it might be — as is indeed the case of cold work. While there is the same opportunity for heat treating a completely welded structure as though it were made by any other process, the practical trend seems to be to avoid this expense by selecting base metal whose good properties are inherent.

Most varieties of resistance welding are done at a temperature below melting, since the hottest metal is squeezed out in a fin or flash.

The heat gradient at the very joint is low, as all the metal between grips is very hot. The joint is also hot worked by the squeezing action, which partly repairs the damage done to the heated zone. As noted in the classification above, various modifications of the resistance process have been devised which restrict the volume of heated metal, or the time it is at heat, or both. Sometimes the time is so excessively short that expected changes in metallographic structure are actually caught half-way, so to speak. (Mr. Adelson's article on the structure of welded tubing printed in November, 1932, in METAL PROGRESS cites cases in point.) In any of the resistance welding processes there is little or no attempt made to cold work the joint, and it is rarely heat treated.

As to forge welding, or its modern counterpart, hammer welding, there is an opportunity for hot work and for cold work. Furthermore, there is ample opportunity to reheat the completed joint. The resulting joint would therefore be nearest the condition of the original metal, and therefore the closest approach to an ideal joint were it not for certain inherent limitations of the process. Chief among these is the fact that the heating is done so slowly and in such equipment that the surfaces cannot be kept metallurgically clean (free from oxide). Furthermore, the temperature range for good jointing is very narrow and difficult to estimate, the amount of hammering is subject to the judgment and fatigue of the operator, and very few varieties of metal can be welded over broad areas in the plastic state.

Thermit welding has pre-empted the field of repair work on massive steel parts, and some other work on pieces of relatively large cross-section, such as rail jointing. A thermit weld is a casting, pure and simple; there is no chance for hot work in the mold, or for cold work or reheating (due to size or fixed location). However, this does not mean that a serviceable joint is not the result, for the proper technique involves adequate preheating to a moderate temperature gradient, and metallurgical skill has progressed so that there is no difficulty in making a casting with strength and ductility equivalent to the plain carbon steel ordinarily joined.

Aside from the matter of convenience and available equipment, therefore, an engineering appraisal of the suitability of welding for a given production or repair job should depend upon the importance of the metal at the joint to the integrity of the structure, the ability to approximate the composition of the metal to be joined, the amount of damage done to the microstructure of the base metal, and the chance that this may be corrected (if necessary) by subsequent work or heat treatment.

Design and welding of structures of any size, or parts of any intricacy, involve other considerations inherent in all methods of welding. These have to do with internal strains, and will form the subject of a later discussion.

Overhead Welding for Closure Joint on Airplane Fuselage. Photo by Hine, N. Y.

Zinc-base die castings, now widely used in automotive construction, have strength and toughness of brass and are equally permanent in shape and properties, even in hot, humid atmospheres. They comprise a new economical material for engineered constructions.

Tough, Strong, Permanent Die Castings

EARLY development of the die casting process took place in the lead-base and tin-base alloys, because the casting of type and type metal was the forerunner of the modern die casting industry. These alloys, however, lacked strength and were soft; consequently their use was quite limited. Introduction of zinc-base alloys offered industry a material that was stronger and harder than the tin or lead alloys, and their use grew rapidly. In the period from 1919 to 1929 the amount of zinc used in die castings was increased some 500%, and the ratio of the amount used in die castings to the total amount of slab zinc consumed in this country grew from 1½% to about 7%. Therefore, zinc-base die castings were about four times as important in 1930, 1931, and 1932 as they were in 1920, 1921, and 1922.

In considering the reason for this growth, due allowance must be made for the increase in automobile manufacturing. The automobile industry has used more die castings than any other; consequently the success of the zinc-base casting has been tied up with the success of the automobile industry. The converse, however, is also true; the success of the modern automobile has been partially due to the reliability of its zinc-base die castings.

It has been stated that the consumer gets more for his dollar today when buying an automobile than in any other purchase. This is perhaps too strong a statement. It is certainly true, however, that effective automotive engineering has lowered the selling prices enormously. It is just as true that die casting has done its share with other semi-automatic processes in this effective engineering.

Automotive engineers as a class are familiar with the advantages and economies offered by zinc-base die castings, and they have been able to take advantage of these economies in designing their product. Leaders in many another industry could well afford to follow their footsteps in this advance.

Another reason for the increased use of die castings, and a reason closely tied up with the automotive use, is the improvement in the zinc-base alloys, at first compounded more for ease in casting than for engineering properties. Immediately following the War the zinc-base alloys were studied in several laboratories, both governmental and private. Numerous investigators have published the results of their findings, and as a result of this work even the poorest die castings of 1933 are as superior to those of a decade before as heat treated alloy

By D. L. Colwell
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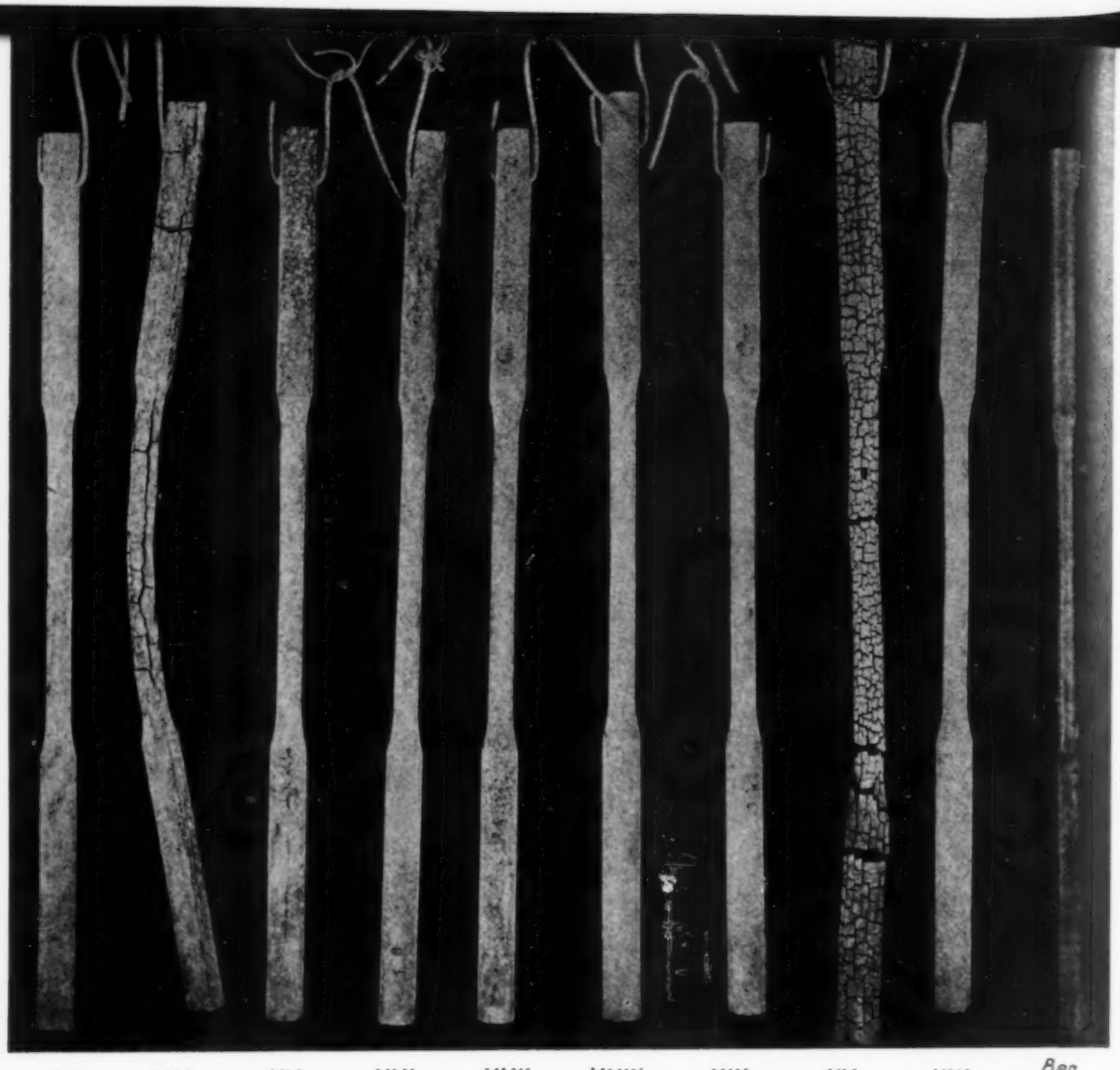


Alloy	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	Bar as Cast
Copper	5%	3%	3%	3%	3%	3%	2%	3%	3%	
Aluminum	0.25	4	4	4	3	0.5	4	4	4	
Magnesium	—	—	0.1	0.1	0.3	(6% Sn)	0.1	—	0.1	
Zinc	H	H	H	S_1	H	P	S_1	S_2	S_3	

Effect of Analysis and Quality of Zinc on Resistance to Steamy Air. See text for explanation of symbols P, H, and S

steel is to cast iron. Thus die castings have kept step with recent metallurgical advances.

One of the most comprehensive of these investigations (as far as utility of the product is concerned) has been sponsored by the American Society for Testing Materials. In 1927, that society, through its committee B-6, enlisted the cooperation of leading producers of die castings and many consumers, as well as the Bureau of Standards and the U.S. Army and Navy. Test bars of specific alloys were cast and tested after various accelerated and natural aging periods. The list of zinc alloys tested is shown below the half tone above, and the view shows the results of one accelerated test made by subjecting the bars to water vapor at 200° F. Correlation of this test with normal service is difficult, but it does serve to show up the weaknesses of certain alloys, and was used for a preliminary survey, pending the results of long-time exposures.

The bar of alloy XX in that figure illustrates what happened to the most popular die casting of 1918 (containing 3% copper, 4% aluminum, and balance zinc of grade S_2 containing no more than 0.25% impurities). By the use of a better grade of zinc *H*, known as "high grade" in A. S. T. M. specifications B 6 — 18 (impurities limited to 0.07% lead, 0.03% iron, and 0.07% cadmium, and the total elimination of tin), alloy XIV was produced. This represents the die casting favored in 1922.

In 1926 the addition of magnesium produced alloys XV and XVI. In the latter, zinc of grade S_1 was used, analyzing 99.94%. The trend, obviously, was the use of zinc of higher and higher purity. When 99.99% pure zinc, *S*,

was used, the impurity lead was practically eliminated, and the resulting alloy is illustrated by bar XXI. When this alloy is artificially aged in 200° F. water vapor, its retention of tensile strength and its very low dimensional change are much superior to those of the other commercial alloys tested. Normal aging of the test bars in exposed and protected atmospheres later proved this same superiority.

The immediate result of this A.S.T.M. investigation was the general adoption of 99.99% zinc and alloy XXI by the die casting industry. During the past three years none of the reputable manufacturers have used anything but 99.99% zinc in any zinc-base alloy containing aluminum. In 1931 the A.S.T.M. adopted tentative specification B 86 — 31 T for alloy XXI, and in 1932 the Society of Automotive Engineers also adopted it as specification 921. The chemical composition and mechanical properties called for in these specifications are given in the table below. The tensile specimens used are die castings whose reduced section is ¼ in. diameter and 2¼ in. long. Impact specimens (unnotched) are ¼-in. square die-cast bars.

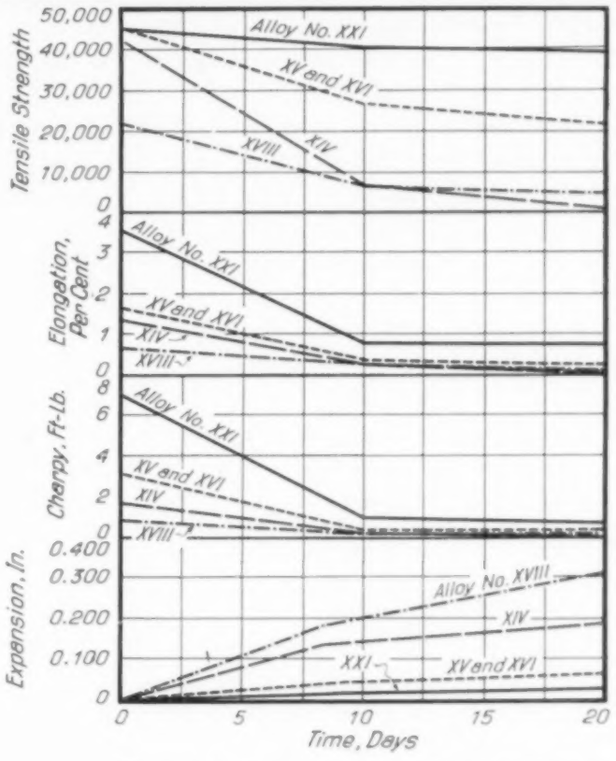
Although the accelerated "steam test," whose effect is illustrated, is commonly used as a check upon the aging qualities of zinc-base alloys, there is a tendency for these effects to be taken too literally and given too much weight in appraising the product's durability.

Specified Composition and Properties of Modern Alloys — *Average of Five Specimen*

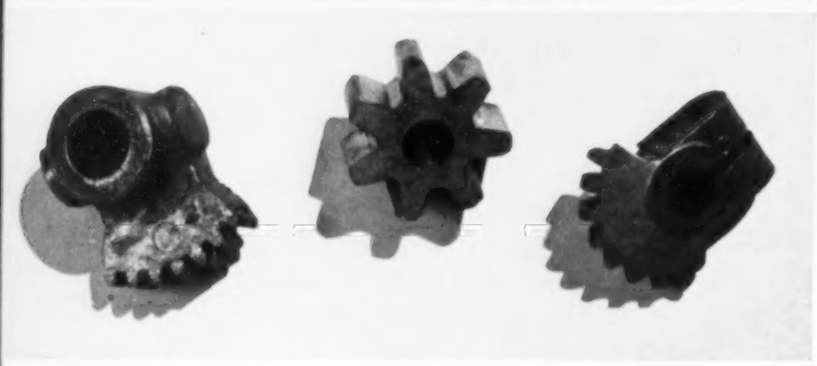
Composition	Alloy XXI	Alloy XXIII
Copper	2.5 to 3.5%	0.10% max.
Aluminum	3.5 to 4.5	3.5 to 4.5%
Magnesium	0.02 to 0.10	0.03 to 0.08
Iron	0.1 max.	0.1 max.
Lead	0.007 max.	0.007 max.
Cadmium	0.005 max.	0.005 max.
Tin	0.005 max.	0.005 max.
Zinc	Remainder	Remainder
Properties As Cast, Minimum Average		
Tensile strength, lb. per sq. in.	44,000	35,000
Elongation in 2 in.	2.0%	3.0%
Charpy Impact, ft.-lb.	6.0	12.0
Properties After 10 Days In Water Vapor at 200°F.		
Tensile strength	30,000 min.	30,000 min.
Elongation in 2 in.	0.5% min.	1.5% min.
Charpy impact	0.75 min.	12.0 min.
Maximum dimension change	0.0025 in. per in.	0.001 in. per in.

Short Vs. Long Exposures

The severity of the test is illustrated by data secured by the above-mentioned committee. It will be noted by examination of the first set of curves just below that the impact strength of all alloys drops rapidly in the steam bath. Alloy XXI is best, but none of the bars has an impact strength of more than 1.0 ft-lb. after ten days in the bath. However, after one year of normal aging in the various locations, the impact strengths have not dropped nearly as much. Initial values of 7.4 ft-lb. (average of bars from five producers) dropped to 4.7 after a year indoors at Hanover, N.M., 4.8 at Cambridge, Mass., or 2.9 at New Kensington, Pa. One year outdoor exposure at Key West, Fla., brought the average impact strength of all bars of Alloy XXI to 2.8 ft-lb., at Sandy Hook, N. J. to 3.89 ft-lb., at Rochester, N.Y. to 4.2 ft-lb.,



Changes in Properties of Die-Cast Test Bars of the Various Analyses Shown on Opposite Page, After Exposure to Steamy Air for 20 Days



Photographs on These Pages Are Examples of Zinc-Base Die Castings (Alloy XXI) Which Have Given Satisfactory and Long Service in Situations Requiring Strength, Impact Resistance, and Permanence of Dimension

at Altoona, Pa., to 3.8 ft-lb., and at New York City to 6.1 ft-lb. On the average, therefore, one year's aging in various exposures cut an original impact value of 7.4 to a new value of 4.3 ft-lb.

The steam bath test, therefore, should be used more as a check upon purity of the alloy than as a prediction of life.

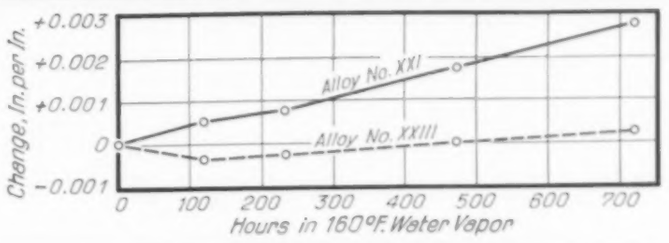
At New Kensington and Key West the impairment has been more severe, probably because of corrosion at New Kensington and tropical humidity at Key West. The salt spray corrosion at Key West and Sandy Hook has caused some pitting, which also affected the impact figures.

Turning again to the long time exposure tests, the drop in impact strength (from 7.4 to 4.3 ft-lb. in one year) is the most serious objection to alloy XXI. Its tensile strength, hardness, and dimensions are reasonably stable. A great number of tests demonstrate that the tensile strength of alloy XXI does not change to any great extent under any of the normal conditions, and even in the very severe conditions of the steam bath it does not suffer a loss nearly as great as does the impact strength. (See the curves on page 21.) None of the dimensional changes in normal aging is serious, as it varies from a shrinkage of about 0.002 in. to a growth of about the same amount in a 6-in. length. Shorter dimensions would have correspondingly smaller changes. The undue severity of the steam bath is illustrated by the greater dimensional changes of accelerated aging noted on the curves.

It follows from these long time exposure tests, which have been amply corroborated by experience, that alloy XXI can be used with safety as an engineering material where heat and moisture conditions are not too severe, and where a somewhat lower impact strength is not a danger. An example where the tensile strength of alloy XXI has proved more than satisfactory for several years of stressed service, is its use as a material for gears and pinions, compressor heads, oil pumps and pressure regulators, some of which are illustrated in the accompanying photographs. An example of an application where the dimensional permanence of alloy XXI has proved more than satisfactory over a period of years is its use as mounting plates for electric clocks. In hundreds of other applications, such as gears, brackets, housings, pinions and frames for meters, typewriters, check protectors, washing machines, slot machines, couplings and radios, where stability has been important, alloy XXI has proved itself entirely serviceable.

Since the A.S.T.M. investigation was started a new alloy has been developed which has overcome the weaknesses of alloy XXI. Considerable experimenting was done as far back as

Expansion of Alloy XXIII in Hot, Moist Air Is Very Low. Changes may be due to relief of internal stresses rather than any structural change



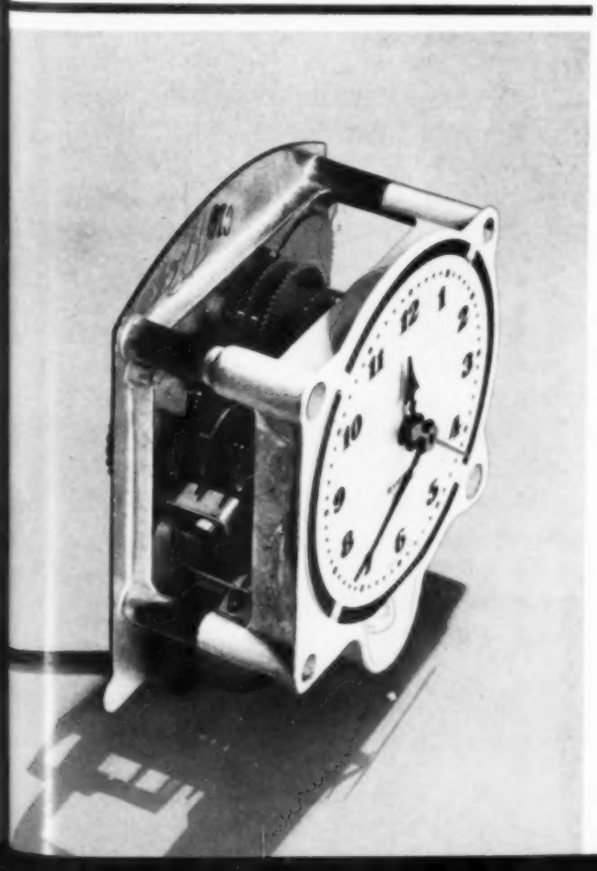
1918 with zinc alloys containing only aluminum as an alloying ingredient. In the absence of copper, these alloys were too unstable to meet with approval, and they were abandoned. However, when zinc of 99.99% purity was used and a minimum of 0.03% magnesium added, it was found that a zinc alloy containing 4% aluminum is more stable and has greater toughness than alloy XXI. It has been specified by the Society of Automotive Engineers as No. 903, and tentative specifications as alloy XXIII have been prepared by the A.S.T.M. committee B-6. Chemical composition and physical properties of this patented alloy are listed in the table on page 21. A longer account of these improved alloys was given in METAL PROGRESS just a year ago.

The superior permanence and greater toughness of alloy XXIII are shown in the minimum values given in the table. Compared to alloy XXI its tensile strength is lower and its elongation and impact strength higher in the normal condition. After ten days in steam, however, the situation is entirely different, particularly in impact strength, for the properties of alloy XXIII after this accelerated aging are in every case changed but little from their initial values, and are then superior to those of alloy XXI. The maximum dimensional change is also much lower.

The permanence of strength of alloy XXIII was strikingly brought out in a test on flexible couplings of both the alloys, tested to destruction in a torsion machine. These couplings were broken after absorbing about 130 ft-lb. of energy. Other samples of these castings were then subjected to 200° F. water vapor for ten days and broken in the same machine. The strength of alloy XXI had dropped to 73 ft-lb., while that of alloy XXIII was still 118. It is speculative to propose a ratio between the steam bath life and life under normal conditions, but it is certain that the ten days in 200° F. water vapor caused as great a change as would years of normal service, and alloy XXIII was still as good as new.

Permanence of dimension was illustrated in another test. Test bars 6 in. long of alloys XXI and XXIII were subjected to 160° F. water vapor for a 30-day period, the bars measured at intervals, and the growth plotted in the figure on the top of this page. Alloy XXI showed an increase in length of over 0.0025 in. per in. at the end of that time, but alloy XXIII had grown less than one-tenth as much. In fact, its initial shrinkage and later growth might well be caused by relief of casting strains followed by subsequent surface corrosion due to the steam.

The use of alloy XXIII should greatly enlarge the field for zinc-base die castings. When designing engineers realize that a die casting may be readily secured having a toughness which may be favorably compared to that of cast brass or malleable iron and equally permanent in shape and properties, they will specify it more frequently. The economies offered by this method of production cannot be overlooked. Automotive engineers have pointed the way; will production engineers also seize their opportunities?



Troubles with decorative coatings may be due to damaged or poorly polished under-plates. Hard coatings require hard steel backing and a fine polish to give a low coefficient of friction. The metal chromium is not particularly resistant to heat nor chemicals.

Information For the User About Chromium Plate

ALMOST any difficult question about the correct use of chromium plate should be readily solved if the requirements are studied and correlated with the known properties of chromium. In other words, a thorough knowledge of the properties of chromium leads to correct application. It is surprising, however, even at this late day, to find many failures due primarily to misapplication — or application in such a manner that the property sought cannot be secured. It should be remembered that while the metal chromium has many wonderful possibilities it is not always an easy matter to obtain them, especially when the chromium is mere plate 0.0001 to 0.010 in. thick.

Decorative Plating — The properties most vital to the user of decorative plate are color (bluish white), hardness (9 on Moh's scale, where diamond is 10), and high resistance to atmospheric corrosion in ordinary weather. For this type of work other properties need not be considered.

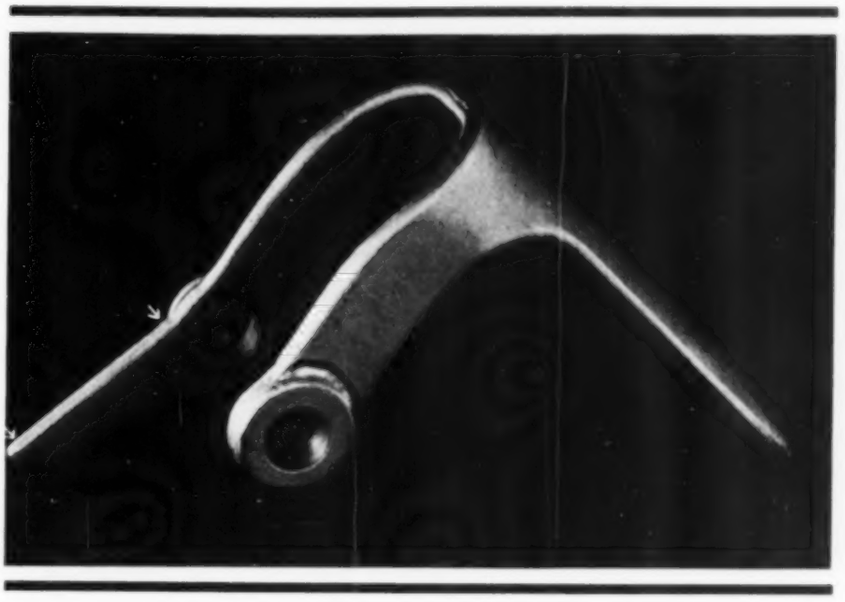
Color is in part a function of the base metal and the polishing program, especially the latter, providing the plating bath is kept constant and operated within the "bright range."

The cost of the article will usually determine the plating specifications. A high class job, calling for a mirror finish, requires careful polishing of the steel and a perfect coat of copper which is not cut through to steel in the subsequent buffing. This perfectly continuous coat of copper is essential for highest corrosion resistance. Any point cut through to the steel will invariably corrode and rust. It is good to remember that copper and nickel undercoats prevent *rust*, while the chromium finish prevents any *tarnish*.

It is, of course, possible and at times advisable to vary from this copper-nickel-chromium combination. If color and high finish can be sacrificed somewhat, the copper may not be buffed. If natural chromium color is satisfactory, the nickel need not be buffed. Such eliminations will not decrease the corrosion resistance of the article. Very recently I have seen the copper eliminated entirely and a very good job secured with nickel and chromium.

Specifications for a high class decorative job of chromium plating should require polishing the base metal to at least 180 emery. The copper plate should then be 0.0025 in. thick and buffed to a high luster without cutting through to the steel. Nickel plate should be 0.0025 in. and color-buffed to a mirror finish. The final chromium plate should be at least 0.0002 in. Just how far a manufacturer should vary from these specifications will be determined by the selling price of the article.

By Marvin J. Udy
Chemical Engineer
Anniston, Ala.



Ingersoll-Rand Chipping Hammer Part, Hard Plated for Wear in Holes and Between Arrows, and Plate Covers All of the Surface for Appearance

There are some uses in decorative work where chromium can be plated direct on steel. These are special cases and are, as a general rule, more costly than the triple coats specified above, because the steel must be more highly polished and a heavier coating of chromium put on. Both corrosion resistance and tarnish resistance are to be secured on such articles by chromium alone; the deposit must therefore be free of pinholes. This requires at least 0.0005 in. of chromium (better 0.001 in.).

The property of hardness is important in decorative work since it protects the finish from abrasion under ordinary use. While resistance to abrasion is due chiefly to the hardness of chromium, even with the very thin coats used, the base metal is also quite important. A soft base such as brass or copper will not back up the chromium sufficiently to prevent scratching a thin coat (of the order of 0.0002 in.) even with the thumb nail. Examination will usually show the chromium pushed into the soft base with a visible checking of the plate.

Resistance to atmospheric corrosion in decorative work is in all probability associated with the hardness and the crystal structure of chromium. It is due primarily to an oxide film. This film, being very thin, does not dull the luster of the bright deposit for a long time. The very thinness of this film and its slow rate of increase make chromium one of the best metals for resisting tarnish.

Heavy Deposits for Wear Resistance

Plating of heavy deposits is far more specific than for decorative purposes. Various other properties of the metal are more important than its tarnish resistance and color.

Chromium plate has been quite successful in combating frictional wear, since the coefficient of friction is one of its most remarkable properties. An accompanying table gives some coefficients of friction, taken from various sources. It is well known that there are two kinds of friction; one is the resistance offered to a force tending to start one body to slide uniformly upon another, and the other is the resistance to the forces keeping the body sliding uniformly. The relation between the pressure with which the two surfaces are pressed together and the force necessary to cause one to slide past the other is called the coefficient of friction.

Combination	Coefficient of Friction	
	At Rest	Sliding
Chromium on chromium	0.14	0.12
Babbitt on chromium plated steel	0.15	0.13
Steel on chromium plated steel	0.17	0.16
Steel on babbitt	0.25	0.20
Babbitt on babbitt	0.54	0.19
Steel on steel	0.30	0.20

Just why chromium has such a low coefficient of friction is not known; possibly it is associated with the hardness and crystal structure. It is worthy of note that the coefficient of friction of steel on babbitt is nearly twice that of chromium plated steel on chromium plated steel, or chromium plated steel on babbitt.

Many of the most successful applications of heavy plate have been due to this property rather than to hardness. One could note diesel engine piston rods, crossheads, compressor rods, and machine parts subjected to heavy wear. Twist drills, chromium plated, have given good results not because of any added cutting quality obtained from the hardness but rather because of the increased clearance or ease of twisting from the low coefficient of friction.

For the smallest amount of wear the plate should be properly backed up with good steel of sufficient hardness that it will not deform under the particular service. For most work a steel with 270 Brinell is a minimum. Illustrations of an application gone wrong from this cause are soft steel piston rods which will not stand the pressure of the packing, and plated main bronze bearings of a locomotive which carry the entire engine weight. Steam-heated rolls for drying machines, made of plated mild cast steel, will not stand the pressure of relatively soft materials passing between them.

Chromium, as it comes from the electrolytic bath, has a high coefficient of friction due to a film formed in the tank. For this reason it is advisable to refinish all heavy deposits of chromium. Do not forget that this removes some of the metal. In the case of plug gages with a tolerance of only 0.0002 in., it was originally argued that 0.001 in. of chromium was sufficient. Such gages proved to be unsatisfactory, but when the gage was cut 0.002 in. undersize, plated 0.003 in. thick, and 0.001 in. ground and lapped off, the gage lasted many times longer and actually became a success.

Another interesting discovery concerns snap gages with a very low tolerance. Gages made of hardened steel are covered with a film of oxide due to grinding, and this oxide greatly cuts down the life of the gage. Chromium plated tools of this type are in all probability coated with a very thin oxide film in grinding, but this film is well within the tolerance limits and consequently a much longer life is obtained.

Photo by Underwood & Underwood

Miscellaneous Properties

Let us now examine some of the other properties of chromium which may have an important bearing on specific uses of plated articles.

Electrical Conductivity of chromium is only 57% that of silver. This means that chromium should not be used where high conductivity is essential. Knife switches carrying heavy loads are made of copper and are subject to corrosion. Such a switch, when plated with chromium, has such a high resistance that the switch becomes excessively hot.

Heat Conductivity — There are not many instances where conductivity of heat would be very important. It should then be remembered that the heat conductivity is only 50% that of silver; however, this figure compares well with other common metals. It is doubtful if this property would be detrimental in apparatus and equipment where a high rate of heat transfer is essential.

Coefficient of Linear Expansion is another valuable property in special uses. The change in length per unit length is about 8.7×10^{-6} per °C., and is very near that of glass, which varies from 7 to 9×10^{-6}. This property is taken into consideration in plating the lead-in wire in electric light bulbs and where metals are sealed

through glass. Platinum has a coefficient of linear expansion of about 9.3×10^{-6} and was used for this purpose until the development of special iron-nickel alloys of correct expansion. Chromium plated wire should be less expensive and even better where the electrical conductivity of the plated wire is sufficiently low.

Reflecting Power of chromium is only about 60 to 70% that of silver. For this reason it has not been used for reflectors, even though it does not dull with age. Silver soon loses its high reflecting power and rapidly approaches that of chromium, and it would appear that chromium reflectors would have a wider application. The only explanation for this condition is the ease with which silver reflectors may be refinished, a process described in the issue of METAL PROGRESS for May, 1931.

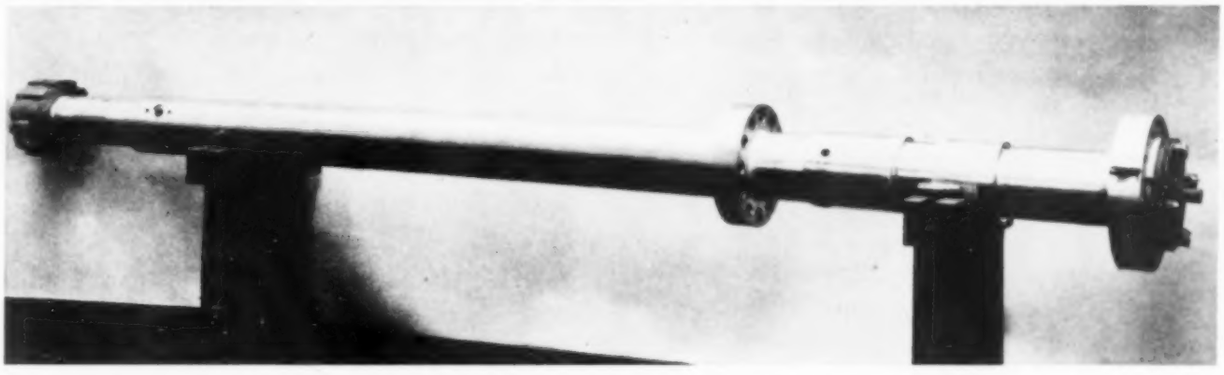
Oxidation and Corrosion — Such problems are so varied in their nature that the only safe way to determine whether chromium plate is suitable is to test it under the conditions of use. Some general facts can be stated that should be useful as a guide:

Chromium plate resists atmospheric corrosion excellently, and there need be no fear of a good plate tarnishing when exposed to ordinary weather for many years.

Chromium is highly resistant to nitric acid. Could the user always be assured of a perfect chromium plate it could be successfully used for such chemical equipment, but unfortunately this assurance is so lacking that it is advisable to use high chromium-iron alloys (18% Cr) for this purpose.

Chromium is passive to cold sulphuric acid and also slightly to cold hydrochloric acid. However, it is rapidly dissolved by either acid, once the passivity is disturbed. It is rapidly dissolved in the hot acids.

Chromium is resistant to the action of sulphur compounds. Thin coatings have been very successful in vulcanizing equipment, such as tin molds, golf ball molds, and rolls for making sheet rubber. It is also resistant to sulphur compounds arising from the refining of high sulphur oils. It has found use in the fiber board industry for combating corrosion of the pulp and also in improving the board surface.



Diesel Engine Piston Rod, 15 Ft. Long, 9 In. Diameter, Plated With 0.003 In. Chromium. Courtesy Worthington Pump & Machinery Co.

Chromium is resistant to alkalies and to organic chemicals, yet it is so difficult to get a perfect plate that this type of corrosion should be combated with alloys and not chromium plate. If the latter is used it should be first tested under the conditions of use.

Chromium plate resists atmospheric oxidation due to heat very well up to 900° F., but oxidizes rapidly at 2200° F. It has worked well in diesel engines and gas engines and is entirely satisfactory for temperatures found in such equipment. Careful thought should be given to uses at elevated temperatures.

Hardness of Heavy Deposits — The extreme hardness of chromium has been a considerable source of difficulty in the successful application of heavy deposits. With *(Continued on page 62)*

This paper read before the International Acetylene Association describes a new method for hardening rail ends and other massive parts, consisting of rapidly heating the surface to just above the critical and allowing the cold metal underneath to withdraw the heat and so quench.

Heat Treatment With Oxy-Acetylene Flame

By J. H. Critchett, Vice-Pres.
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THERE is some previous history which can be used as the basis of our expectation that the use of the oxy-acetylene flame for hardening or annealing of steel and iron will continue to grow. As long ago as 1925 a survey of such uses was made, and from information received from literally hundreds of members of the American Society for Steel Treating, an imposing list of applications was collected. In nearly every instance they comprised what might be called "differential heat treatment" (that is, the treatment of minor areas of a piece) thus leaving the bulk of the material unaffected. In this great group of economical operations, the most popular applications were the hardening of high speed and carbon tool bits, tappet ends on gas engine valves, and wearing spots on all varieties of machine parts. Spot annealing of hard carburized parts, of work-hardened stampings, or of castings afflicted with hard spots, comprised a second large subdivision. A summary of these findings was published in *Oxy-Acetylene Tips*, February, 1926.

Much recent work has increased our knowledge of the way the process can be used, refined the methods, developed new controls, and given added impetus to its application to industry. Among the earlier uses which have survived as regular manufacturing methods are the hardening of valves and certain types of saw teeth. The former operation is illustrated on the opposite page, and represents the value of the method for local hardening of metal parts having the very highest quality. Also there are numberless instances where the hand welding torch has been used both for local hardening and annealing in repair work, or in an emergency, or in regular production where only a few parts were involved.

Another application where the method has been used rather widely is for the hardening of gear teeth. There seem to be a number of instances where concerns have developed methods using the hand torch for the latter purpose. In fact, quite a controversy has arisen in the technical press in England as to who was the first to use the method in that country. Some years ago A. E. Shorter developed a machine for hardening gear teeth in a more or less automatic manner. The Shorter method did not make any headway in this country largely because the apparatus failed to meet our conditions satisfactorily, but did make considerable progress in England. The process was described in *Metallurgia*, November, 1932. An account of a somewhat similar method for hardening bearing surfaces on crankshafts, developed in Germany and known as "Doppel-Duro," was

given in METAL PROGRESS, January, 1932, page 72.

The application of oxy-acetylene hardening which has received the widest publicity in this country is the hardening of rail ends. I believe the Chicago, Milwaukee & St. Paul Railroad was the first to do this in a large way.

Self Quenching of Rail Ends

By their method a welding blowpipe is used to heat the top of the rail to a temperature above the recalescence point. The hot metal is then quenched by pouring a definite amount of water on it. This leaves the running surface at the rail end in an extremely hard and brittle condition, and a second reheating with an oxy-acetylene flame is necessary to reduce the hardness to the desired degree. The temperature for quenching is determined pyrometrically with a very interesting contact thermocouple, and the temperature of drawing is controlled by the simple expedient of heating until a piece of solder drawn across the surface will melt and slightly tin the hot steel.

This process has the advantages that it can be done in track, that abutting rail ends are hardened simultaneously, that the apparatus is readily portable, and that the controls are suitable for use in the field by regular track welding crews. A full account of it was given by M. D. Bowen before the International Acetylene Association three years ago, and published in METAL PROGRESS in March, 1931.

A more recent and still further improvement of the method of hardening rail ends by the oxy-acetylene method has been put into practice during the past year by the Oxweld Railroad Service Co. It differs radically from the earlier method in the use of a very much larger oxy-acetylene torch and the elimination of water quenching and the second heating inherent in the old process.

This new method depends upon the use of a sufficiently large oxy-acetylene flame so that the surface of the rail to be hardened can be brought to a proper temperature before the deep-seated portion of the rail head has been materially heated. Thereupon the flame is

Certain Gas Engine and Aircraft Engine Valves Made by Thompson Products, Inc., Are Hardened by Self-Quenching. Valves are almost submerged to restrict heat to very tip end of the hardened stem

Heating Relatively Small Masses of Metal With Large Flames Will Anneal the Spot. In this view the operator is softening metal around one of the holes in a Ford tail lamp shell, stamped of stainless steel, for an extra draw

removed, and simple conduction of heat makes the cold rail act as the quenching medium; the rate of quenching is such that the surface at the end is left automatically at the desired hardness.

A fact which may at first seem surprising, though not on second thought, is that the process is (for practical purposes) independent of air temperature, winds, and other outside influences. In fact, the method has been used with equally good results whether the surrounding temperature was 20° below or 110° above zero. This is, of course, due to the fact that the results are controlled principally by the conduction of heat by the metal and this is proportional to the difference in the temperature between the heated surface and the cold rail. The steel must be heated above 1400° F. in order to be hardened, and when the hot metal is at this high temperature, there is not a great deal of difference in the temperature gradient whether the cold metal is at 0° or 100° F.

A great many measurements have shown that the Brinell hardness of the treated metal has been increased about 100 points. For example, if the original hardness of the rail head was 260, the treated metal had hardness of 350 or better. The final hardness of the rail is controllable within certain limits, although the greater the surface hardness, the shallower will be the thickness of the hardened layer.

The apparatus and the method have been applied successfully to many different sections of rail ranging in weight from 100 to 135 lb. per yard, and the pattern of the hardened area can be controlled almost at will. In various stretches of track that have been treated, workmen have hardened as many as 60 or more joints per hour, and this is the chief reason for the economy of the operation.

Advantages of this process over other methods of hardening rail ends are its cheapness, freedom from complicated controls, the superiority of the technical results, and the fact that it is practically fool-proof. The speed with which the operation is carried out leads to economy in gases, and the crew is small, so the actual cost per joint is very low. Degree of hardness can be controlled within desirable limits, and the nature of the operation is such that if the operator for any reason varies from the standard conditions which have been set for him the rail will be left in a safe condition (which would not be the case, for instance, if inadvertently the second drawing operation were not carried out on a rail that had been quenched from a high temperature).

This method of heat treatment depends on two things: The heat conductivity and the heat capacity of the metal integral with the part that is being heat treated. Both of these are inherent properties of the steel not subject to change, but whose laws are understood and hence capable of direction. The heat conductivity of steel is sufficiently high so that this factor does not usually require special consideration.

However, if there is a necked section or restricted portion between the portion that is being heated and that which is to act as a

quenching medium, complications may arise. Since the unheated portion of the steel is to serve as the quenching medium, it must bear such relation to the highly heated part that it can quickly absorb the quantity of heat above the recalescence point in the part to be hardened. The balancing of these factors (that is, the quantity of heat above the recalescence point and the capacity of the rest of the metal to absorb heat) determines the rapidity of the quenching and hence the hardness of the part being treated.

It is well known that the volume changes which occur during the hardening by water quenching introduce dangerously high internal stresses which are only partly relieved by the drawing operation. This fact has doubtless caused many conservative officials in maintenance-of-way departments to hesitate before adopting any practice that would tend to endanger the rails — obviously a most essential precaution toward safety. The system of heat treatment whose application to steel rail has just been described should remove the cause of such objections, since it is the simplest and most logical method of avoiding extreme quenching and hence the internal stresses that may follow when that method is used. There is a gradual transition in the body of the steel from the normal unaffected metal to the localized hardened spot at the very rail end, where extra hardness and toughness are urgently desired to resist batter from the wheels of passing traffic. The industrial importance of the process may be gathered from the fact that rails are replaced in main-line, high-speed track more because of bad conditions at the ends, making a rough-riding track, than because of general wear or deterioration.

Application to Heavy Machinery

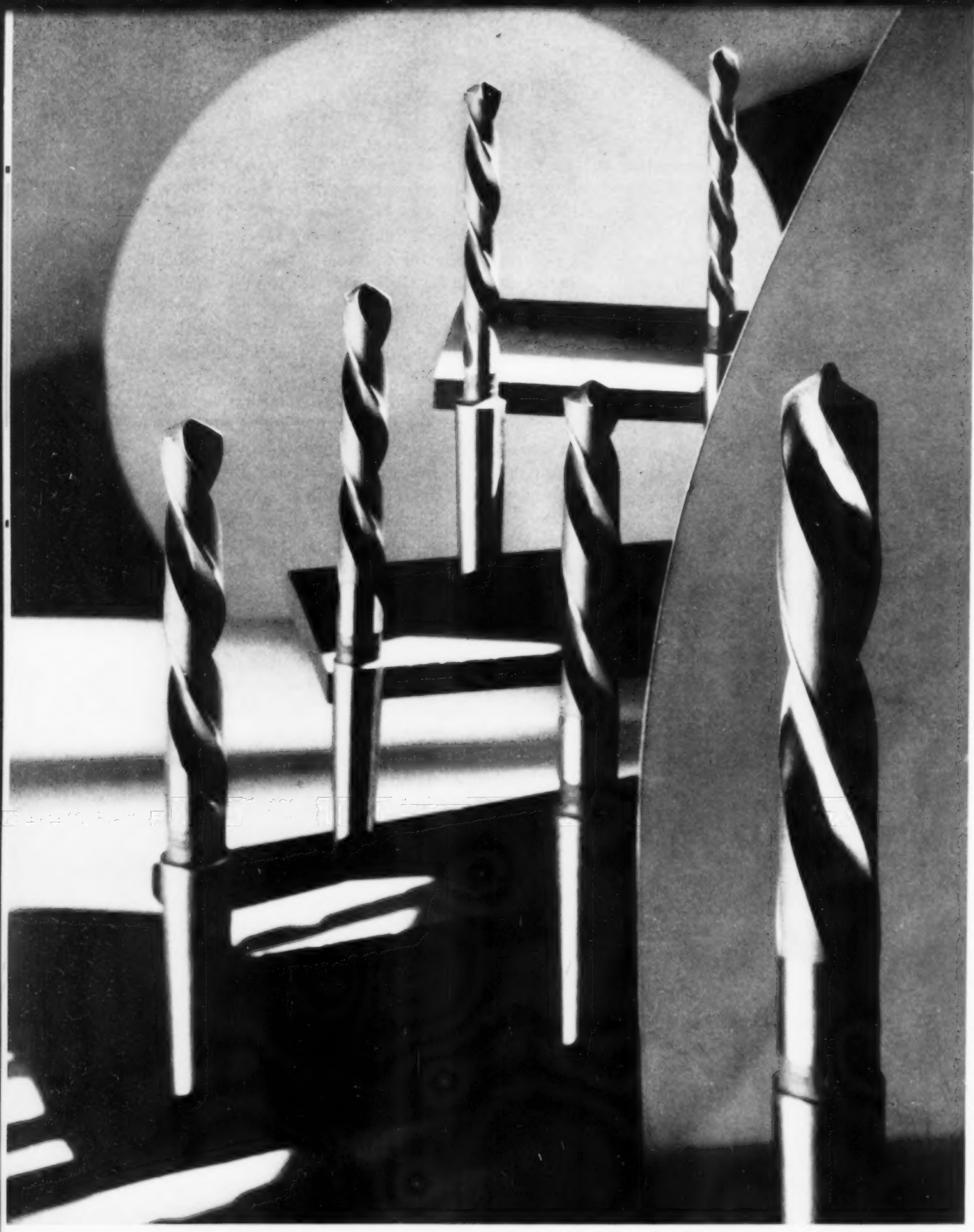
This method is suitable not only to rail but to many other steel parts, and has been applied to such things as lathe-bed ways, bearings on shafts, dies and many other parts. In these applications it has frequently enabled the designer to substitute fabricated steel for iron or steel castings, has eliminated the necessity for case carburizing, or has taken the place of heat treatment of a complete unit.

Substitution of steel fabrications, or "weldings," for castings has been noted so often that it is no longer news. It is less frequently emphasized that such fabrications may logically be made of several different grades of steel, each best fitted for the service it is to withstand. What more natural than that portions that must resist wear should be of higher carbon steel, whereas portions that must absorb shock should be of softer, ductile steel?

The further ability to harden such a structure locally enables one to put the part subject to wear in a very satisfactory condition to withstand the service it must meet, while at the same time the rest of the machine has the advantages of increased toughness and strength. Case carburization of certain areas is thereby eliminated, and we are substituting the oxy-acetylene hardening process, which can be carried out economically in minutes, for one that requires many hours of time and expensive furnaces.

Where the new method takes the place of the old standard heat treatment methods, it has a distinct advantage due to its ability to be applied to a part of, instead of the whole of, the steel structure. Heretofore it has often been necessary for the engineer to make a compromise, either heat treating the whole in order to have high hardness at the location where it is necessary or not having the hardness desired at some particular location through inability to allow such hardness throughout the whole. Often inability to make such a compromise requires an undesirable complication of design and fabrication.

This new method of heat treatment will find many further applications. Needless to say, it requires intelligent care. In addition to a thorough knowledge of oxy-acetylene equipment (particularly as to the handling of large volumes of gas), metallurgical knowledge is required in order to apply the process correctly to the many grades of steel which are now met in the industrial field, each of which responds to heat treatment in its own peculiar way. Considerable mechanical ingenuity is often necessary to adapt the method to production. However, knowledge of the kind necessary is available and widespread, and as this technical method becomes more generally known, its use will grow proportionately.



Courtesy of Cleveland Twist Drill Co.

Editorial Comment

High Quality in Industrial Art

WE ARE continually receiving favorable comment on the beauty of the photographs reproduced in METAL PROGRESS. Most of the commentators seem to think that such fine photographs are hard to get — perhaps the impression arises because so few technical magazines have an interesting appearance. As a matter of fact, they are fairly plentiful, probably because skilled photographers realize that modern machinery and machine products frequently have beauty of line and fine balance and coordination of parts. As remarked in a lecture the other day by Donald R. Dohner, Director of Art for the Westinghouse Co., these are the very attributes of art which are present in a fine building, a beautiful mural, or a piece of sculpture. METAL PROGRESS, therefore, is merely using resources now ready on every hand.

use metal « use metal » use metal

Light Metal in Bridge Floors

EVEN railroad men — those old conservatives — are finally waking up to the fact that aluminum at 26¢ a lb. may be cheaper than steel at 2¢ when you have to haul it around the country as so much dead weight, year after year. Few would think of it as a stuff for bridges, yet there it is!

An important traffic artery in Pittsburgh crosses an old bridge which has been worked closer and closer to the safe limit. Finally it was closed until it could be rebuilt or strengthened. Keen thinking by someone suggested a third way out — to lighten the floor system. That proved to be cheapest, for 350 tons of heat treated aluminum shapes and plates now does the duty of 850 tons of structural steel, and the old trusses now can carry 500 tons more live load — a safe margin for the present.

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Internal Stress — We Can't Escape It

INTERNAL stress has been a bugaboo to users of fine metal ever since the first tool cracked on quenching, the first brass urn split open even while standing idle on a shelf, the first train was wrecked by a transverse-fissured rail, or the first boiler cracked through a riveted seam. While overpowering external loads make themselves evident in no uncertain ways the worry comes in the thought that many other articles are just on the verge of failure at a time when life and property would be endangered.

Despite much study, the problem of estimating these internal stresses remains unsolved, although in practice the danger is minimized by "stress relieving anneals," or by changes in the working conditions or surroundings. The favorite method of study has been to measure a piece of suspected metal, remove a thin layer and measure the piece again, compute the forces necessary to cause the difference in size and say that this is internal stress in the part removed. This method is very laborious and applicable only to simple shapes. X-ray studies have been touted to solve the problem, but the indications of plastic strain and preferred orientation in any spectrogram far overshadow those of internal stress. Magnetism and "damping characteristics" of the metal apparently hold more promise as indicators, although these researches have not yet got very far.

It should be remembered that an internal stress is not always improper or harmful. For instance, any hardened steel is probably highly stressed, atom to atom — in fact, one plausible theory of hardening is based on this assumption. Again, strengthening by cold work involves the same internal stressing — this is not pure hypothesis, as the amount of energy rendered latent in hard drawn copper wire has been measured. But even admitting that hardening by quenching or cold work involves large internal stresses, the margin between it and the ultimate strength can be widened by a gentle tempering. If we banish internal stress we must get along without quench-hardened or cold worked metal, and shrink fits.

A metal wholly without internal stress and strain is probably found only in the liquid state. The very act of freezing sets them up. The manufacturing problem is to avoid pieces wherein they vary sharply in intensity or direction from point to point, nearly exhausting the ductility of the fabric, and leaving little or no margin for useful work. So far that problem has been solved by cut-and-try methods, which of course is bad only because every now and then some epidemic of trouble arises, due to carelessness, ignorance, or a wholly unexpected set of new conditions.

Theoretically, the problem is excessively complicated, but that only means that its solution will involve an unusual amount of careful work of a fundamental nature, and it is well that systematic work along this line is being undertaken by the Metals Research Laboratory at Carnegie Institute of Technology.

use metal « use metal » use metal

Jobs for Riveters

IN ONE of his recent lectures sponsored by the Cleveland Chapter, A.S.S.T., Robert E. Kinkead estimated that there exist at present in shops throughout the United States no less than 200,000 oxy-acetylene blowpipes, 30,000 arc welding machines, and 15,000 resistance welders. These are imposing figures and possibly may be challenged. However, they harmonize with news from England that the shop courses designed to teach welding are full of students who are out-of-work riveters!

Better and Better Gray Iron Castings

DURING 1933 there appeared no less than five major articles in METAL PROGRESS on improved cast irons, which measures somewhat the great amount of study recently given to common gray iron. Past-President A. E. White has said that no branch of metallurgy is receiving more intensive study, and the result is a marked revival in the uses of cast iron, reversing the tendency of former years when many had observed that the tried and true material was on the decline, and some had predicted that the loss was permanent.

It is natural that the automotive industry should be the most conspicuous user of high strength castings, for special irons in cylinder blocks have been used so long they have ceased to be "special." But even if some one, ten years ago, had told that progressive group of men that we would today be using cast iron camshafts, the prophet would have been hooted. But here they are, along with an ingenious type of cast iron brake drum, produced under most rigid control.

Of course, it is not all smooth sailing for gray iron foundries. Intense competition from alloy steels, sheet steel, and non-ferrous materials has shouldered cast iron entirely to one side — at least for the present — in many places. In others a merry battle still wages, as for instance between brass, zinc die castings, and gray iron for small parts on carburetors and other auxiliaries, and between aluminum and gray iron for pistons and cylinder heads.

Large question marks are erected as to the continuing use of gray iron in other places. For instance: Weak parts of today's engine are the piston rings, and they are being given close study. Engine blocks are also causing trouble at the valve seats, especially in high speed engines burning ethyl gasoline. Tungsten steel or stellite inserts have been used by some designers, but their expense and the difficulty of joining them to the cylinder block tightly enough to conduct heat are both indications that the correct solution has not yet been found.

All this boils down to: "Watch cast iron! It's moving fast."

use metal « use metal » use metal

Plain carbon tool steel is still pre-eminent for cutting non-abrasive materials where the service does not heat the tools. Deeper and faster cutting calls for high speed steels. Abrasive objects require diamonds or cemented carbides. Certain of the non-ferrous alloys are useful as tool materials

Materials For Modern Cutting Tools

THE INCREASING complexity of our modern life is nowhere better exemplified than in the increasing number and variety of materials available for our cutting tools. It is apparent from the enormous number of uses to which cutting tools are put and the variety of materials employed for tools that the property rather vaguely known as "cutting quality" is complex. In the problem of selecting a material to cut some definite substance, other factors than "cutting quality" may enter — for instance, ease of fabrication and cost. With our modern methods of production, the manner in which the tool is to be used is also a principal consideration; for instance, it may be a hand tool or it may be a tool to be used for heavy duty production work in high powered machines.

In an unpublished paper considering methods of selection of the most suitable tool materials, written for the American Society of Mechanical Engineers, the writer enumerated the principal attributes which appear to be essential and to what degree each attribute is really necessary. The following text is based upon that paper.

A certain degree of *hardness* is required by every cutting tool. This must be materially greater than that of the material being cut, but there is usually a limit beyond which a further increase in hardness may be useless or even undesirable. As an illustration, a steel saw for cutting wood requires only a very moderate degree of hardness. It should be possible to resharpen it with a file. A considerable increase in hardness would add but little to its resistance to wear and would make it much harder to sharpen with a hand file.

Similarly, it may be shown that such properties as strength and toughness have a minimum value which is absolutely essential. It may be said that a higher degree of these qualities would always be desirable and could do no harm in itself. The practical limitation may be that an increase in the values of these properties can only be obtained at extra cost or by the sacrifice of a part of the hardness or wear resisting ability.

The property of *strength* plays a larger part in the make-up of cutting quality than is generally recognized; if one material is to cut another at commercial speed it must have a strength definitely greater than that of the material being cut. The minimum degree of *toughness* required may be said to be an amount just sufficient to enable the tool to resist the stresses and shocks incident to its manufacture and use without breakage. To this may be added sufficient toughness to insure the cutting edge itself

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against a prohibitive amount of cracking, chipping, and crumbling. Good examples of materials in which low values of strength and toughness limit their usefulness are found in the sintered carbides.

The *cost* of the tool is an important attribute. Take the case of a milling cutter needed only at long intervals for short jobs. Such a tool may be economically made of carbon steel; 18-4-1 high speed steel might be about the maximum permissible expense.

The *workability*, or ease with which a material may be fabricated into tools, frequently has a considerable effect upon the degree to which it is utilized. Thus, many intricate punch press dies would be difficult to make from one of the cast, hard metal alloys.

With these general principles in mind, a brief survey will now be made of the most common materials in commercial use, commenting particularly upon such of their attributes as appear to be largely responsible for such commercial popularity as they enjoy.

Carbon Tool Steel

Materials for cutting tools may be generally divided into (*a*) steels, and (*b*) non-ferrous materials, which include such materials as diamonds, most abrasives, the hard carbides, and some of the hard metal alloys.

In considering the tool steels, the oldest and simplest form is the alloy of iron and carbon commonly known as "carbon tool steel," or "water hardening steel." While its former universal field has been invaded and limited by a multitude of new alloyed materials, it still maintains a wide usefulness and well-deserved popularity for a large variety of cutting tools to work on metals, wood or fabrics.

Some of its most valuable attributes are: The great hardness which can be imparted to it, which is greater than that of many of its alloyed competitors; its toughness, especially under shock; its ease of fabrication; the easily varied degrees of hardness or temper which can be imparted to it; and finally its low cost. These valuable qualities have firmly intrenched it for hand tools, tools subject to severe shock, and tools which encounter only low operating temperatures. Its low cost compared to other tool materials renders it economical for many intermittent operations, particularly where relatively few parts are to be made. Examples of tools for which it is still widely used are hand reamers, bit stock drills, blacksmith drills, small wire size drills, hand taps and thread cutting dies, numerous kinds of tools for use in wood, brass, aluminum, lead, zinc, and similar easily machined metals and alloys.

Many tool steels now on the market frequently contain alloying elements such as chromium and vanadium in amounts of less than 0.5%, to impart valuable properties to the steel without removing it from the commercial classification of carbon tool steel. For example, many contain about 0.15% chromium, added for the purpose of holding the carbon more firmly in combination with the iron and preventing its precipitation in the form of microscopic particles of graphite. Other steels containing about 0.50% chromium have been deservedly popular for cutting tools on account of their ability to harden uniformly to a great depth. Carbon steel drills in sizes larger than one inch in diameter are usually made from this grade of steel.

Intermediate Alloy Steels — Chromium, tungsten, molybdenum, and manganese, in amounts of 1% or higher, are frequently added to tool steel. Sometimes this is done with the idea of increasing the cutting quality and sometimes in order to make the steel oil hardening. Commercial tools made of such steels are usually marketed as "carbon" tools. Sometimes tools with about 1.00% of tungsten have been marketed as "semi-high speed steel tools," a classification to which they were not entitled.

Tool steel containing from 1.00 to 1.50% of chromium is oil hardening and it develops a good degree of hardness and excellent toughness together with a high resistance to wear. An unusually wide range of useful properties can be imparted to it by variations in heat treatment. Its ease of fabrication and its low cost also contribute to its popularity.

Tool steel containing from 1.00 to 1.50% manganese is also oil hardening and is frequently used for intricate tools where there is great danger of warping or fire cracking in the hardening operation if made from plain carbon steel and quenched in brine. It has been par-

ticularly popular for die work and for forming tools.

Other intermediate alloy steels of higher alloy content have been used for special requirements. A good example is the steel with about 4% tungsten, 1% chromium and 1.40% carbon, used for fine finishing tools taking only light cuts, and also for dies where great resistance to wear is required under low operating temperatures. Some makers also add small amounts of vanadium to this steel. Molybdenum steels are used to some extent in the field intermediate between carbon and high speed steels.

A recently introduced type of oil hardening die steel employs 12% or more chromium and 2.00% carbon; in air hardening varieties minor additions of vanadium, cobalt, or molybdenum are made. Such steels are used for cold heading and coining dies where great resistance to wear is desired. They have been found to be quite resistant to moderate operating temperature. As is indicated by its analysis, it is closely allied to the stainless steels.

High Speed Steel

The most widely used steels for production tools are of the type known as high speed steels; the most prominent is the well-known "18-4-1"—that is, 18% tungsten, 4% chromium, and 1% vanadium. It is used for the great majority of mass production operations and is a universal standard of comparison for cutting quality. The peculiar property distinguishing it from carbon or low alloy steels is its ability to maintain its hardness, strength, and cutting quality at high operating temperatures—1100° F., which is a low red heat, and sometimes higher—while carbon steel tools start to deteriorate at operating temperatures in the vicinity of 500° F. However, it should be emphasized that where operating temperatures of 400° F. are not exceeded at the cutting edge, there is usually very little advantage to be gained by using high speed steel instead of carbon steel.

Several other types of high speed steels are on the market in limited quantities. One containing approximately 14% tungsten, 4% chromium and 2% vanadium has excellent cutting properties but is handicapped by having such a narrow hardening range that extremely accurate heat treatment is necessary. A type containing about 15.00% tungsten, 4.00% chromium, and 0.50% vanadium is quite popular in England, but has not equalled the 18-4-1 type for the high duty production requirements of this country. There are also some European steels which contain as high as 20 to 23% tungsten.

Many attempts have been made in the past to improve the composition of the 18-4-1 type of steel and many are still being made. A great deal of the popularity enjoyed by this standard type of steel would appear to be due to its general utility for many varied purposes and its wide application in many fields. It is easily fabricated and has a fairly generous range of temperatures in which the heat

Carbon Steel Tools Are Ordinarily Chosen for Small Tools and for Cutting Brass. Photo by Rittase at Allan Bradley Co., manufacturers of electric equipment

High Speed Steel Is Available in a Number of Minor Modifications Suitable for Severe Service on Strong, Tough Non-Abrasive Metal. Photo by Mudd at Midvale Co., manufacturers of fine steels

treatments may be satisfactorily conducted. The carbon content may be varied over a considerable range in order to secure steels especially fitted for particular uses. For instance, a carbon content of 0.40 to 0.50% is used in dies for hot work. The variety with carbon content from 0.70 to 0.80% is used where a high degree of hardness is required and where high toughness is not essential. For general purposes carbon contents are from 0.60 to 0.75%.

Some efforts have been made to produce a "super" high speed steel by increasing the percentages of the essential alloys (tungsten, chromium, and vanadium) but they have not attained wide commercial use, so that the results obtained have hardly justified the increased cost. Efforts have been made to improve high speed steels by additions of small quantities of such elements as uranium and tantalum as well as by greatly increasing the vanadium and carbon contents. The effect of such additions is not yet fully understood but at least it can be said that no such steels have as yet become generally accepted.

In the last few years there has been an increasing use of cobalt as an additional alloy in high speed steels of the general 18-4-1 composition. Several containing cobalt in the range 4.0 to 14.0% are now commercial, while still higher percentages have been tried experimentally. A certain degree of popularity has been achieved by this type of steel, particularly for lathe tools and tool bits. The demonstrated advantages have been (*a*) a certain increase in hardness which is, however, attained at the expense of some of the toughness of 18-4-1; and (*b*) a widening of the range of temperatures in which satisfactory hardening may be obtained. In other words, the cobalt makes the steel more fool-proof in heat treatment, it being less likely to be damaged by overheating or underheating in hardening and likewise showing a useful degree of strength and hardness at any drawing temperature up to 1100° F.

Some steel makers add about 1.0% molybdenum to their 18-4-1 steels, especially if they contain cobalt, but the results obtained from it are not very apparent. Other makers use as a basis for their cobalt high speed steels the 14-4-2 type; in this steel cobalt widens the hardening range so that tools can be uniformly heat treated with ordinary commercial precautions.

The possibility of making high speed steels in which molybdenum is used as the principal alloying constituent has long been known. A much-discussed type contained 9.0% molybdenum, 4.0% chromium, and 1.0% vanadium; however, no such steel has as yet achieved a considerable degree of commercial utilization. It has recently been discovered that the addition of a minor amount of tungsten to molybdenum high speed steel greatly increases its cutting quality, and such molybdenum-tungsten steels are now commercially available, having become popular for hacksaw blades, while their use for other tools is increasing. A detailed account of investigations on "Some Molybdenum High Speed Steels" is reported in *Transactions*, A.S.S.T., March, 1933, by the present author.

Non-Ferrous Tool Materials

The most widely used non-ferrous material for cutting tools is without doubt the grinding wheel. The rapid improvements made during the past generation in the utilization of abrasive wheels as cutting tools have been no less than revolutionary. They have resulted from the development of artificial abrasives such as aluminum oxide and silicon carbide, together with improvements in wheel manufacture and the better design of grinding machines.

Where grinding wheels were formerly used largely for sharpening and smoothing operations, they have now become economical for the removal of such quantities of stock as formerly required turning, milling, or planing. They have also made possible the shaping of materials so hard that they were previously considered unmachinable.

The diamond as the hardest known material has notable usefulness as a cutting tool. Its particular field lies in the machining of substances which are so hard or abrasive as to be difficultly machinable or perhaps unmachinable by other cutting tools. Its largest field is doubtless in the turning and resurfacing of abrasive wheels. It is used for fine finishing operations, such as the turning of bearing metals and abrasive non-ferrous alloys. In the form of dust it also has a highly specialized but indispensable field for lapping other extremely hard materials.

In another class of non-ferrous cutting tools are the "hard metal alloys." One type of cobalt, chromium, and tungsten alloy has been in commercial use as a cutting tool for many years under the name of "stellite." This alloy must be cast and ground to its finished shape; its hardness is inherent, that is, it requires no heat treatment to develop it. The principal property which has made it of commercial importance is its ability to retain hardness at a high operating temperature, probably several hundred degrees higher than high speed steel will withstand. At low operating temperatures its hardness and its resistance to wear appear to be less than some tool steels.

Alloys of iron, cobalt, and tungsten or molybdenum, in which carbon is a non-essential impurity, are a new development, described in METAL PROGRESS last February. They are malleable and machinable and therefore can be formed into intricate tools, and then can be heat treated to a hardness comparable to that of high speed steel. This hardness is not lost during long operations up to 1100° F., a temperature that softens many high speed steels. It appears that the useful field for such alloys will be for tools to operate at temperatures above those which high speed steel will stand.

Hard Carbide Compositions

Development of cutting tools utilizing the extremely hard carbides of tungsten, molybdenum, titanium, and tantalum has excited universal interest. These tool materials are made both by fusion and by sintering with a tenacious binder, usually cobalt. The sintered products have attained the highest degree of commercial utilization. These materials are characterized by great hardness and rigidity with a fair degree of strength and a low toughness. When machining abrasive materials of low strength such as graphite, hard rubber, slate, or asbestos compositions, their ability to withstand wear is truly phenomenal, but when working on materials of great strength and plasticity such as the steels, their wear resisting qualities have been less noteworthy, and utilization has been limited to improved mixtures of tungsten carbide with minor amounts of tantalum or titanium carbides.

In machining cast iron, more success has

been attained where it has been possible to increase the cutting speeds until high working temperatures are generated. A real field for carbide cutting tools lies in machining abrasive materials which have been previously considered unmachinable. Their lack of toughness is a serious limitation. At present the difficulty of fabricating them and their high cost have limited them largely to work where long, continuous production runs are involved.

Nitrided cases and chromium plate have been used for hardening the surfaces of cutting tools to better enable them to resist abrasion. The weakness and brittleness of these cases limit their field of usefulness.

A Specific Illustration

As an illustration of the way in which the general principles previously discussed may be applied to the utilization of the available tool materials, the case of twist drills for use in four such widely different materials as wood, machinery steel, 12% manganese steel rails, and carbon electrodes may be considered.

Drills for wood need a moderate degree of hardness and strength but a high degree of toughness. In the drills for machinery steel a higher degree of hardness and strength is required than for wood, but a lesser degree of toughness. In the drills for manganese rails, the highest possible degree of hardness and strength is required, together with the maximum obtainable rigidity, while the requirement for toughness is only moderate. In the drills for carbon electrodes, the principal requirement is the ability to resist the severe wearing action of the electrode composition on the drill point.

In the selection of suitable materials for these drills, choice might logically fall upon carbon steel for the wood drill, 18-4-1 high speed steel for the machinery steel drill, cobalt high speed steel for the manganese rail drill, and sintered carbide for drilling carbon electrodes.

As an illustration of the manner in which the selection may be still further specialized, it might be considered that the drills for wood were of three different sizes or designs, the first of which was a small, simple drill, the second a very large, massive drill, and the third was of a special design in which there was great danger of cracking in the hardening operation. The steels selected for these three cases might all be commercially known as "carbon steels" but actually the requirements of the first case might be best served by a plain carbon steel, of the second case by a 0.50% chromium steel, and of the third case by an oil hardening 1.20% chromium steel.

In some cases modern machining requirements may be best met by a composite tool which uses a combination of several materials in order to secure a tool of greater utility than could be produced by any one of them alone. An example of this is a reamer of the inserted blade type in which the principal cutting edges may be composed of one of the sintered carbides, secondary cutting edges of hardened high speed steel, auxiliary pilots or guides of nitrided alloy steel, while the body may be made of machinery steel. Another example is the case of a drill with cutting edges of a relatively weak and brittle sintered carbide composition which are strengthened and supported by a body of strong and tough, hardened, high speed steel.

The Tool Materials of the Future

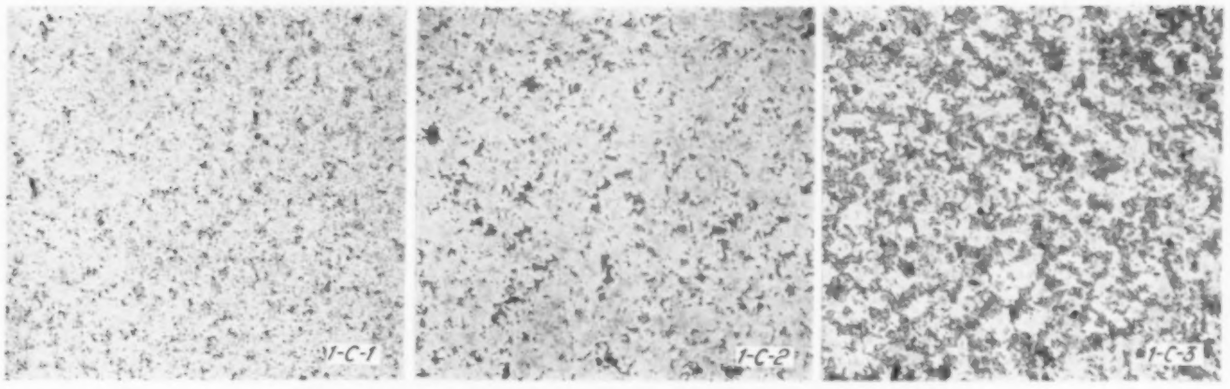
As to the developments in the search for better and cheaper materials, it is difficult to predict. There are, however, certain trends which seem likely to continue. It may be confidently expected that the future will bring forth tool steels which are better than those now in use as well as some that are cheaper. Indeed, the simultaneous achievement of increase in quality with decrease in price is entirely within the bounds of possibility.

The field of the non-ferrous hard metal alloys has been but very little explored and there are many possibilities of valuable additions to our available tool materials from this source. The utilization of the sintered carbides as tool materials has advanced so rapidly that further improvements in quality and reductions in the cost of production seem probable.

It seems improbable that any single tool material will again succeed in dominating the entire field of cutting tools. It is more probable that the future will see an increasing number of useful materials, each filling a specialized need in our industrial organization.

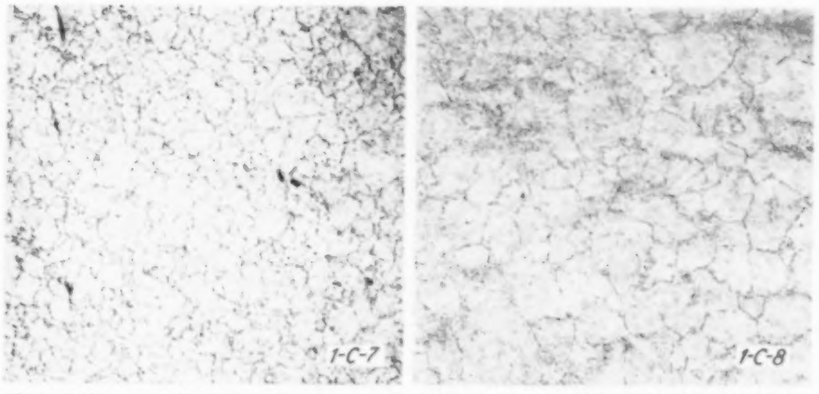
METAL PROGRESS DECEMBER, 1933; PAGE 41

Martensite with Pearlite or Cementite



Martensite With Pearlite, Undissolved on Heating for Quenching

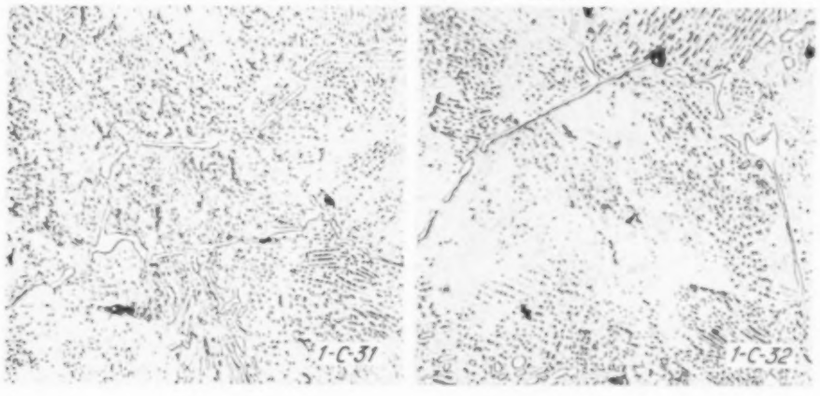
100 Diameters. For micros at 1000 dia. see data sheet published in September, 1933



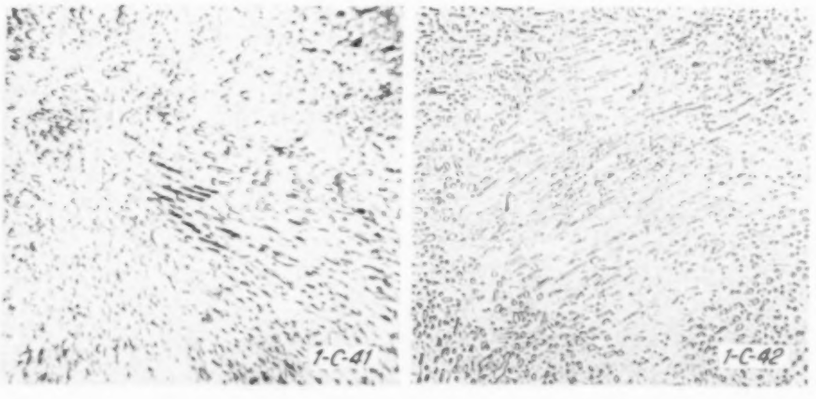
100 Dia.

Cementite Grain Boundaries in Martensite

The boundaries were present before hardening and usually occur in annealing at high temperatures (above A_{cm}) and cooling at fairly rapid rate, such as the cooling rate of the average small furnace



1000 Dia.

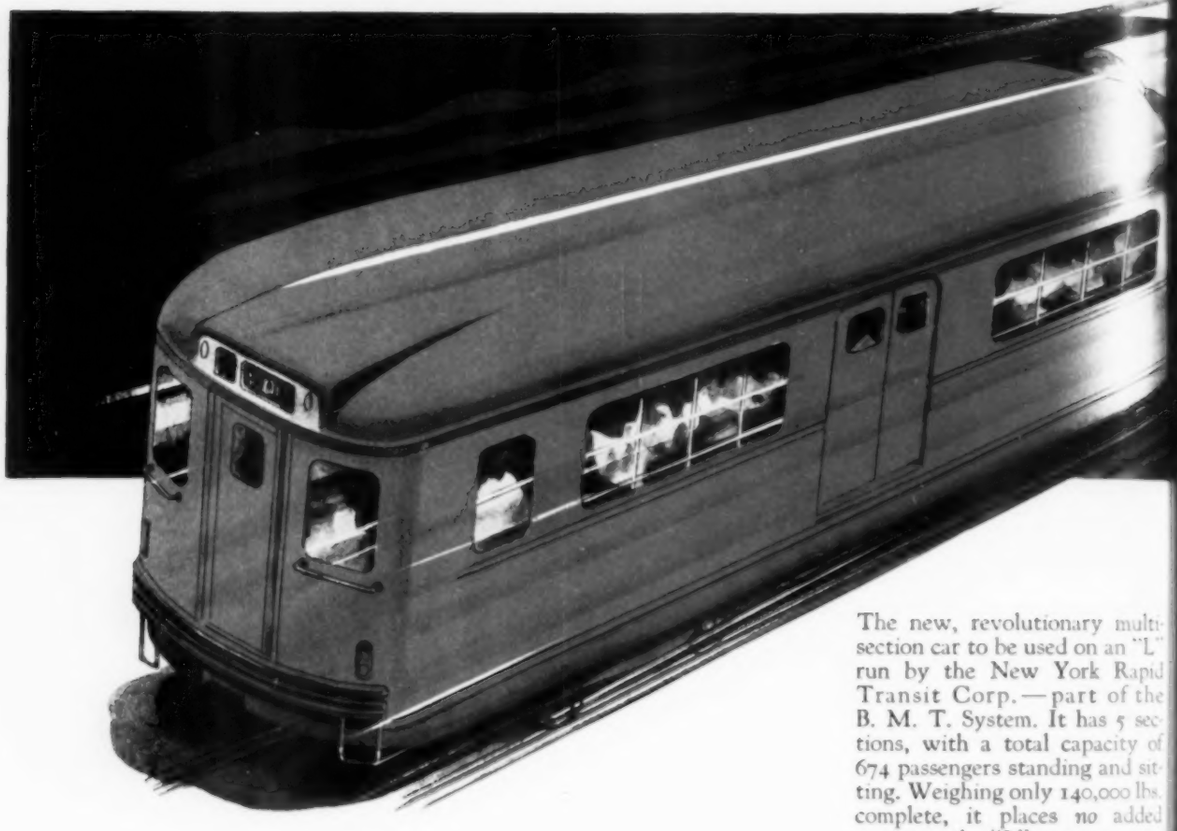


Martensite Structures With Lamellar Cementite

These structures occur after annealing at too high a temperature, and too short a heat before quenching to dissolve the cementite plates. 1000 diameters. Etchant: 1% nital

This plate completes a set of eight, prepared by SKF Research Laboratory, representing the structure of high carbon steel. Other plates were published in September and November, 1931, and January, September and October, 1933

ALCOA *Aluminum* makes Rapid Transit Rapider



The new, revolutionary multi-section car to be used on an "L" run by the New York Rapid Transit Corp.—part of the B. M. T. System. It has 5 sections, with a total capacity of 674 passengers standing and sitting. Weighing only 140,000 lbs. complete, it places *no* added strain on the "L" structure, yet safety is actually *increased* for the light weight Alcoa Aluminum alloy structural parts are thicker and sturdier. Alcoa Aluminum alloys are used throughout. They produce rapid, comfortable, safe acceleration and braking—saving 80,000 lbs. of useless deadweight over heavier construction materials. This multi-section car will make the present 101-minute round trip in 75 minutes, yet will cost less to operate.

IN its never-ending search for safer, swifter, service, the community transit industry is turning, as is all transportation, to the light, strong alloys of Alcoa Aluminum. Eliminating tons of needless weight, yet actually making structural parts thicker, sturdier, *safer;* providing smoother acceleration and braking, higher speeds with lower power and maintenance costs—Alcoa Aluminum is proving itself the ideal metal for all transportation. And that includes railroad cars, elevators, truck bodies, mine cars—every case of mass in motion.

ALCOA ALUMINUM

er and Safer

★

gives all industry new speed, economy, style

THROUGHOUT industry, Alcoa Aluminum brings efficiency to production, salability to the product. Lighter in weight, yet strong as structural steel—non-contaminating, non-magnetic, high in heat and electrical conductivity, it meets the requirements of every type of plant equipment. It makes products lighter, more attractive, too. Even in paint, Alcoa Aluminum as a pigment protects plant surfaces from smoke, rust, weathering, acid fumes; brightens up interiors.

We'll be glad to show you how Alcoa Aluminum can help in your business—also how to use, form or handle this modern metal. Address, ALUMINUM COMPANY *of* AMERICA; 1801 Gulf Building, PITTSBURGH, PENNSYLVANIA.

PES THAT GROW OLD GRACEFULLY—ith metal parts of ALCOA Aluminum, pes attain the mellowness of age with the citing cleanliness with which they started t. For ALCOA Aluminum is easy to keep an; is not attacked by compounds distilled om tobacco in the process of smoking.

HEAT: WHERE AND WHEN YOU WANT IT—Made of ALCOA Aluminum, this portable heater is light in weight, easy to move from room to room. It's lastingly attractive; ALCOA Aluminum's high, even heat conductivity increases its efficiency and eliminates "hot spots."

MAKING LITTLE ONES OUT OF BIG ONES—This ice and ice-cube crusher, made of ALCOA Aluminum, is sturdy and strong enough to do the job—yet it is light enough for even a child to operate with ease. And let's not forget its attractive appearance, that *stays* attractive.

NRA

ALCOA ALUMINUM

Letters From Abroad

Steels for Automatics and Headers

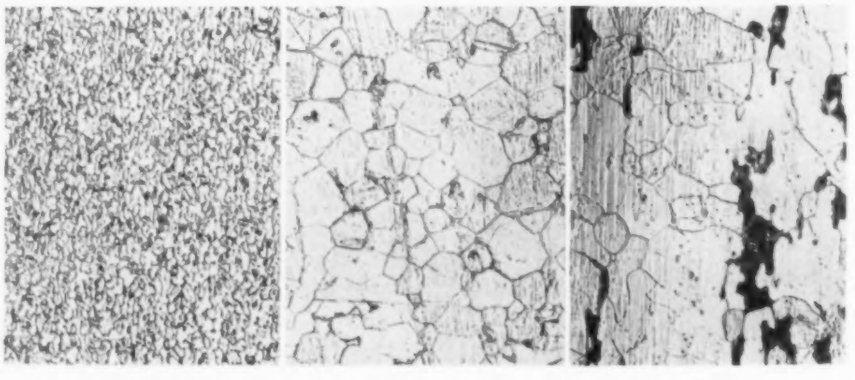
SCHWEINFURT, GERMANY — Much interest is now being shown on the properties of "automatic" steels — that is, cold drawn rods or wire for screw machines or for heading into various kinds of fasteners and other articles. Representatives of the roller bearing and cycle industries reported on this matter to the Committee on Materials at the recent meeting of Verein deutscher Ingenieure. What follows is taken from that report as to the three main fabricating requirements, namely, (*a*) machinability, (*b*) good heading properties, and (*c*) case hardening without soft spots.

Uniformity is the first consideration. Uniformly high quality of the delivered steel is more to be desired than a higher quality in some shipments, followed by others not so good.

As to *machinability:* — There is no testing procedure now available to measure accurately the machinability. No alternative remains but to judge the steel by its effect on the cutting tool, when the tensile strength and elongation are within proper limits. There is considerable difference in machinability from one delivery to another, which it should be the aim of the steel works and rolling mills, as well as wire drawing establishments, to eliminate. Meanwhile, each shipment must be tested for strength, elongation, analysis, and structure.

Experience indicates that machinability depends mostly upon the breaking strength, elongation, and chemical analysis — at least when cutting bars $\frac{3}{16}$ to 1 in. diameter (the usual sizes). Fine grain is also to be desired, tending toward the structure shown at the left of the group of three, rather than the other two. Non-metallic inclusions, when present, should be small and uniformly distributed, as shown in the photomicrograph on page 45.

The breaking strength should not be less than 70,000 nor more than 92,500 lb. per sq.in. Should the tensile strength fall to the range between 55,000 and 65,000 lb. per sq.in., difficulties will be encountered in machining because the chips will be too ductile and too long. Should the tensile strength be above 92,500 lb. per sq.in.,



Good Steel for Cutting on Automatic Screw Machines Should Tend Toward Very Fine Grain as at Left Rather Than the Coarse Structures Shown. Magnified 100 diameters

the steel will be too hard; short, brittle chips are formed (which are desirable), but the surface will be rough, and worst of all, the life of the tool will be short. (This is for cutting speeds of about 125 to 200 ft. per min.)

Heading Properties — The properties which are responsible for good cold riveting or heading qualities are somewhat in opposition to those lending good machinability. The steel is therefore manufactured in such a way as to provide the optimum relationship between machinability and rivetability. It is especially unfortunate that cold forming or upsetting is in most cases the last fabrication process, so that defects occurring then are debited for the entire fabrication cost.

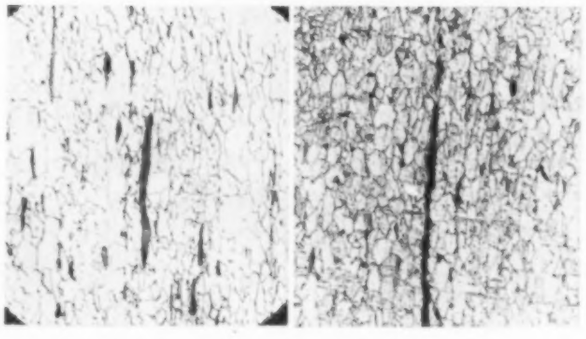
A tensile strength of 92,500 lb. per sq.in. is the upper limit for machinability as well as for upsetting. Tensile strength below 70,000 lb. per sq.in. with correspondingly higher elongation would be favorable to riveting qualities, but is not so desirable for machinability. Tests must therefore determine whether the forming properties (sometimes called the ductility) will be adequate if the tensile strength is in the range for good machinability. Elongation is highly significant, and should be 10 to 15% on a gage length of 10 diameters. The tension test thus becomes a simple and practical method of judging both machinability and rivetability, within certain limits.

However, the heading of sample rivets in a device manufactured for this purpose gives positive proof in doubtful cases. A compression test is also useful; the sample has a height equal to twice the diameter, and no cracks should appear when it is squeezed down 50%. If any hairline cracks are present (due to imperfectly welded gas holes in the ingot), they will also be indicated, as well as rolling defects and grooves from scratched drawing dies.

Case Hardening Properties — It is often very difficult to obtain uniform hardness, depth, and transition zone in the commercial case hardening operations. Since the method of steel manufacture is the determining factor for this property, that large subject will be reserved for later discussion. It may be said that the McQuaid-Ehn test is used to control all shipments which go into hardened parts.

Chemical analysis and stability (non-aging properties) are also closely linked to the method of steel manufacture, and have important influence on the above three properties, and especially upon the endurance of the completed product. While a number of steels are in use, there are three principal varieties of low carbon steels favored by German metallurgists — (*a*) one with medium sulphur, high phosphorus and manganese, (*b*) high sulphur basic steel and (*c*) high sulphur acid steel.

HANS DIERGARTEN

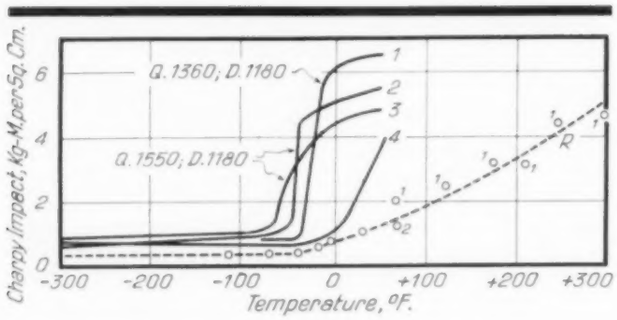


Slag, if Present, Should Be Uniformly Distributed Small Particles, as Shown at Left, Rather Than Present in Large and Segregated Inclusions (Right). Magnified 100 diameters. Ferrite grain size in both samples is about right

Rail Failures in Siberian Winters

GROSNY, U.S.S.R. — Brittleness of metals at low temperature is a matter of great anxiety to the operators of the Siberian railway lines. Fractured axles, tires, engine frames, and especially rails are frequent during the severe winter weather and are a constant source of danger. Rail failures were particularly numerous three winters ago, when temperatures frequently dropped to 60° F. below zero.

The engineering department of the Tomsk Railroad has published a table showing the monthly number of rail replacements for two years, together with maximum, minimum, and average temperatures. Four general types of failures are differentiated — (*a*) cross-section fractures, (*b*) split heads, (*c*) pieces broken out, (*d*) miscellaneous defects. Since the first category is associated with brittleness, and is by far the largest in number, the Siberian officials have



Impact Strength of Rail Steel (R and 4) and After Heat Treating to Sorbitic Structure (1, 2 and 3)

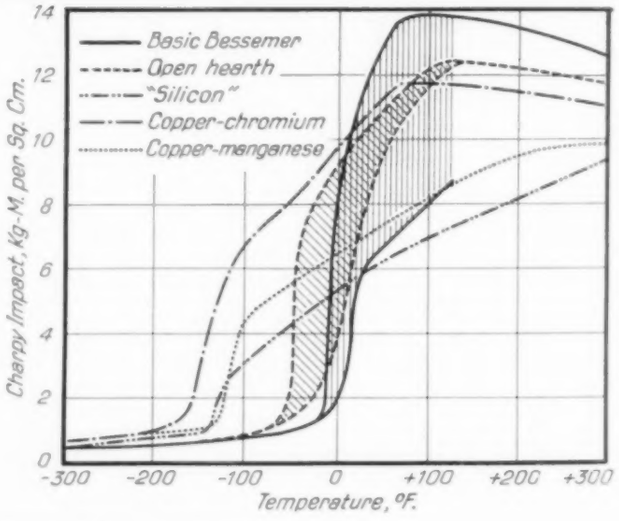
attempted to determine the cause and the remedy.

If the number of broken rails removed from track is plotted, month by month, and the minimum atmospheric temperature is noted on the correct ordinate, the two graphs are almost completely parallel. The total number of broken rails reached maximums on February, 1929 (296), and January, 1930 (818), when the temperature dropped to 43 and 53° F. below zero, respectively. During the four winter months in 1928-29 (December through March) 826 rails were removed from track due to cross-section fractures, and in the corresponding time the next winter 1330 rails were found broken. This means that on the comparatively short Tomsk Railroad, about one in 400 rails may be expected to break during an average winter.

In order to acquire some facts about the brittleness of rail steel at low temperatures, Messrs. Federov and Dobrovidov of the Technical Institute in Tomsk made some impact tests on 10-mm. Charpy notched bars cut from broken rails at temperatures ranging down to liquid air.

As shown by line R on the first diagram, the impact strength of 4.5 kg-m. per sq.cm. at 300° F. decreases almost in a straight line to 0.3 kg-m. at —40° F., and then remains approximately constant down to —300° F. At these low temperatures the fracture is flat, crystalline, and appears to have broken with no plastic flow whatever. As the temperature increases from zero, the broken surface gradually changes to a more fibrous condition, and at 200° F. acquires a dull, dark color, with obvious signs of permanent deformation before failure.

While a true explanation of the above facts has not yet been given, it would seem that the brittleness is principally caused by temperature rather than variations in the usual impurities in the steel. Phosphorus has been blamed, but the broken rails have been analyzed and the content is low and generally well within the specified limits. Furthermore, it is generally understood that all varieties of steel are brittle at liquid air temperatures. Perhaps it is an inherent characteristic. Nevertheless it is important to find out whether some steels which could be commercially manufactured into rails



Steel	Analysis							Heat Treatment	
	C	Si	Mn	P	S	Cu	Cr	Temperature °F.	Cooling
Basic Bessemer	0.04	0.01	0.37	0.066	0.046	0.09	—	1700	Air
Open hearth	0.15	0.01	0.57	0.024	0.030	0.18	—	1700	Air
"Silicon"	0.15	0.89	1.12	0.053	0.036	0.10	—	1560	Furnace
Copper-chromium	0.15	0.36	0.87	0.022	0.026	0.85	0.51	1560	Furnace
Copper-manganese	0.19	0.50	1.09	0.016	0.025	0.60	—	1560	Furnace

German Investigators Have Studied the Toughness of Low Carbon Steels at Sub-Zero Temperatures, and Find That Annealed Steels Having Fractional Percentages of Common Alloys Are Much Superior

will be considerably tougher than 0.3 kg-m. per sq.cm. at Siberian temperatures (zero to —60° F.).

Samples of this relatively high carbon steel rail already in track were heat treated and tested by Prof. Dobrovidov to determine the effect of microstructure on toughness at sub-zero temperatures, and the results are plotted at top of page 46. The raw steel (curve 4) was considerably tougher than the samples from broken rails, even though it contained 0.10% phosphorus. Certain specimens were tested after quenching in oil from 1360° F. and drawing 2 hr. at 1180° (curve 1). Curves 2 and 3 represent samples oil quenched from 1550 and drawn 4 and 2 hr. respectively at 1180° F. Similar results were obtained on another rail containing 0.05% phosphorus and 0.60% manganese. Any of these treatments which produces a uniform sorbitic structure gives metal from four to ten times as tough (at the low temperatures of operation) as the rails as rolled, and the practical problem seems to be that of producing rail with uniform sorbitic microstructure throughout its entire section.

Some recent investigations in Germany and America have a bearing on this subject, as they indicate the effect of method of manufacture and chemical composition on low temperature brittleness. Thus, the second set of curves is from work by Messrs. Rotscher and Fink of Aachen on low carbon structural steels. (Chemical compositions are shown in the table.) The low carbon steel made in the basic bessemer converter is quite tough — although erratic — at room temperatures, but is quite deficient at Siberian winter temperatures. The low alloy steels, especially the copper-chromium steels, are much superior in toughness under those severe conditions.

These results as to normalized low alloy steels were confirmed by Messrs. Egan, Crafts, and Kinzel in METAL PROGRESS, September issue.

The conclusion may be drawn that European rails, which are generally manufactured by the basic bessemer process, are not suitable for Siberian lines. In order to reduce the low temperature brittleness of open-hearth rails, they must either be heat treated to proper microstructure, or be made of suitable alloys, or both.

B. M. SUSLOV

Use of Revolving Furnaces for Small Steel Castings

TURIN, ITALY — Very interesting results from a technical and commercial point of view have been obtained recently when melting low carbon steel for castings in a revolving furnace, such as I have already described in my letter of April, 1932. (Some of these furnaces are already in operation in the United States.)

The first complete experiments on a commercial basis were made by Fours & Appareils Stein of Paris, in their works at La Courneuve, using furnaces of the Stein-Brackelsberg type. The excellent results thus obtained have been fully confirmed by a great number of large-scale trials and have resulted in the installation by many European steel foundries of revolving furnaces primarily for the manufacture of small castings. In this service the advantages of the new process are really remarkable.

Very few alterations are necessary in the well-known revolving furnace as generally used for the manufacture of special iron castings to make it suitable for the production of small steel castings.

The principal advantages of the new process, when compared with the converter, the small open-hearth furnace, or the electric furnace, may be summarized as follows:

1. Much lower cost of installation.

2. Greater facility in producing an excellent and quite constant quality of metal. Frequently foremen who have made nothing but iron castings and completely lack any experience in steel manufacture have been able to melt low carbon steel scrap suitable for castings with complete success.

3. Lower cost of production, due especially to low fuel consumption, but also to the durability of the furnace lining made of cheap materials, the comparatively short time required for melting and refining operations, and the low melting losses.

In addition to the above-mentioned advantages of the new process, other special advantages arise from the specific working conditions in a given shop which may sometimes outweigh all other considerations.

Take for instance a foundry making a great number of small steel castings. The short dura-

tion of heats in the revolving furnace makes it possible to use a comparatively small furnace for the production of a good daily tonnage, even while greatly reducing the weight of each heat. It is unnecessary for us to argue about the great technical and economic advantages of this simple fact.

To take a practical example: An oil-heated Stein-Brackelsberg furnace of one ton capacity (when used for the manufacture of small castings requiring very hot metal) can pour 16 to 17 heats in 24 hr. from a charge of small steel scrap and turnings. This includes time for minor repairs and maintenance. Under the same conditions on the molding floor, this daily output would require an open-hearth or electric furnace of 3 to 4 tons capacity, and individual heats too large for making very small castings conveniently.

On the other hand, if three or four 1-ton electric furnaces or converters were used, the cost of the metal would be about 80% higher. This last figure has been confirmed in numerous instances by costs obtained in foundries operating a revolving furnace simultaneously with a small converter or electric furnace. Some of these installations have worked under constant conditions for many months. In every case the results have proved that the revolving furnace gives the best practical solution of the particular problem above mentioned.

The same conclusion was reached for many other technical problems connected with the manufacture of special steels and irons — either alloy steels, alloy irons, or high strength cast irons.

FEDERICO GIOLITTI

Fundamentals of the Basic Process for Steel Making

PARIS, FRANCE — During the meeting held by the Société des Ingénieurs Civils commemorating the discovery of the basic processes of steel making, the writer, as president of the society, remarked that the success of the basic converter process invented by Thomas (and on which depends so much of our own steel production) depends on three fundamental factors:

1. A fundamental principle in metallurgy — the notion of chemical equilibrium between slag and melted metal.

2. A practical means of carrying out a given operation — the problem of a durable lining for the furnace.

3. A question of economics. This requires a rapid operation, which is in turn the immediate consequence of a rapid approach to chemical equilibrium.

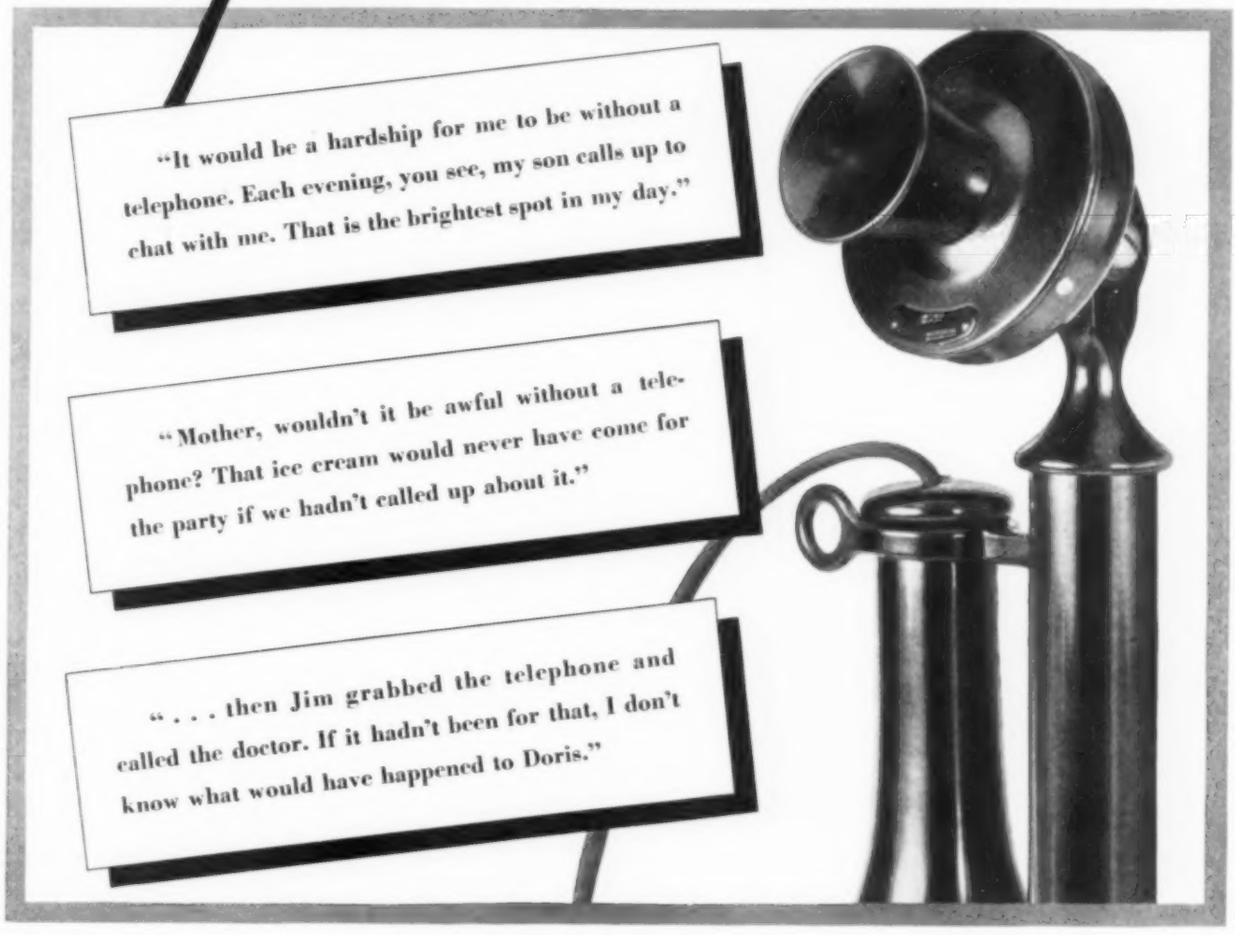
Bessemer's discovery fixed the minds of metallurgists in his day on those internal combustions arising within the bulk of the molten metal from exothermal reactions (which are consequently out of equilibrium and speedy). His process could be explained with the ideas then prevailing about thermochemistry. But such an explanation says little or nothing about the formation of the slag. It was considered chiefly as the outlet for reactive products and as the unavoidable residue.

Thomas' process took into consideration the part the slag plays as a chemical factor, acting by contact with the liquid metal. Its chemical composition depends both upon the degree of dephosphorization and the degree of oxidation that the metal may reach. The reactions which form it are reactions tending toward equilibrium, and therefore are reversible ones. Consequently the whole process is ruled by the laws of chemical mechanics.

A great mass of experiment and theory has brought us to our present understanding of the essential basis of every metallurgical operation circumscribed by the equilibrium positions that define the accurate limits where the chemical compositions of metal and slag must simultaneously arrive. The proverb "Birds of a feather flock together" may be paraphrased by the metallurgist who, examining a piece of steel, is inclined to say, "Tell me about the slag used to refine you and I can say what you are!"

But as the principles of theoretical mechanics are rigorously confirmed only by celestial mechanics, where friction is suppressed, so the principles of chemical mechanics are rigorously applicable only at high temperatures. Then chemical friction disappears within the very fluid materials, so that the reactions at surfaces in contact may be almost instantaneous. It is therefore just as important to speed up the reactions and to increase the area of contact surfaces in order to reach the equilibrium that automatically governs *(Continued on page 50)*

A *Friend* in the house


"It would be a hardship for me to be without a telephone. Each evening, you see, my son calls up to chat with me. That is the brightest spot in my day."
"Mother, wouldn't it be awful without a telephone? That ice cream would never have come for the party if we hadn't called up about it."
". . . then Jim grabbed the telephone and called the doctor. If it hadn't been for that, I don't know what would have happened to Doris."

THERE are many fine things in life that we take almost for granted. Health, water, sunlight, green fields, loyal friends, a home to live in. . . . Not until some mischance deprives us of these priceless possessions do we learn to esteem them at their true value.

It is in much the same manner that most people regard the telephone. Millions of men and women have never known what it is to be without one. Each day, each week, each year, they use it freely, casually, as a matter of course.

The telephone has won an important place for itself in life and living because of service rendered. To keep friend in constant touch with friend, to help manage a household smoothly and efficiently, to give larger scope and opportunity to business of every kind, to protect loved ones in time of unexpected danger . . . this is the task of the telephone.

It stands ever ready to serve you — to carry your voice and your words to any one of millions of other telephones in this country or in foreign lands. You are in touch with everything and everybody when you have a telephone.

AMERICAN TELEPHONE AND TELEGRAPH COMPANY

WHY NOT

A "NEW DEAL"

IN

CYANIDE POTS?

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of this Cyanide Pot *before* using would have discovered the Internal defect which opened up in service causing premature failure.

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surface inspection methods would *not* disclose these defects.

Quality **can never be cheapened.**

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HIGH TEMPERATURE EQUIPMENT

Correspondence

(Cont. from page 48) the chemical composition and that secures a uniform product, as to speed up the operations and thereby decrease the costs.

In the course of the converter process, the puddling or intimate mixture of slag and metal is one of the most powerful factors of rapid reaction. However, the fluidity of the slags existing during a blow in a Thomas converter is far from satisfactory, since these slags are heated only by contact with the melted metal. Auxiliary heating is not practical; the best that can be done is to work rapidly.

As the slags appearing in steel-making processes contain precisely the oxides (silica, lime, alumina, magnesia) constituting the industrial refractories that form the furnace linings, these linings necessarily react with the molten contents and influence the formation or the evolution of the slag as they waste away. For all that, we may say that every metallurgical problem, every successful operation in the metallurgy of iron, involves a problem of lining which is the more pressing as the operation takes a longer and longer time. A notable example is the Thomas-Gilchrist process, which required first of all the discovery of an adequate lining — adequate chemically and mechanically.

Progress in metallurgy will come from a better and wider knowledge of the equilibrium conditions between slag and metal. This will enable the steel maker to quicken the operations, and will free him, partly at least, from the thraldom of the lining. Thorough scientific studies are now being carried out on the equilibrium between slag and metal both in specially equipped laboratories and through large scale experimentation in various steel works. This work is being pursued vigorously at several places in Europe, and also in the Pittsburgh region in the United States.

As an example of the progress which has already occurred in France as to the speeding up of operations, the reader may refer to the note published on page 49 of the February number, on "Instantaneous Refining Reactions in Slag-Steel Emulsion."

ALBERT PORTEVIN

MOLY

makes steel easier to weld

MOLYBDENUM is practically the only alloy used in steel which does not interfere with welding. In airplane construction, where strength and light weight are of paramount importance, welding and Moly steels have gone hand in hand. The welds have proved tougher and stronger, with less embrittlement of surrounding areas. Indeed, Moly is often used in the coatings of welding rods to improve the quality of the weld.

In the well-known 18 and 8 stainless steel, now attracting the attention of engineers, Moly additions of about 2% to 4% are being used to increase desirable characteristics, particularly resistance to acid corrosion. It is interesting to note that a Molybdenized stainless steel does not require the usual surface polish to resist corrosion.

Moly always improves steel. Increases tensile strength, creep strength and resistance to wear. Gives a superior steel at a "competitive" initial price and a lower cost for the finished product. The modern Climax laboratories in Detroit and the Climax metallurgists are prepared to prove these points. Write for details about our free engineering and experimental services and an interesting new book: "Molybdenum." Climax Molybdenum Co., 295 Madison Avenue, New York City.

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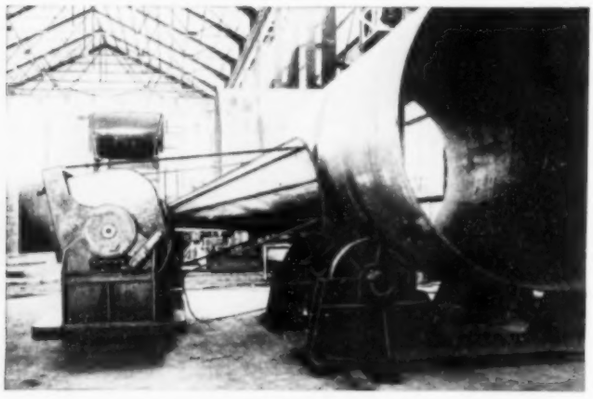

FOUR 300,000 volt x-ray units will shortly be in operation in the Babcock & Wilcox plants. Two are now in use, one at Barberton, Ohio, and the shock-proof outfit shown above "on location" at the Boulder Dam Project.

One of the pioneers in the industrial use of the x-ray, B & W soon found their G-E x-ray unit an invaluable tool for the non-destructive inspection of fusion welds in plate up to 4" in thickness. When faced with the gigantic task of x-raying 75 miles of seam in the Boulder Dam penstocks, they naturally turned to G-E for the necessary equipment. A 300,000 volt shock-proof unit, with all high tension parts oil-immersed, was adapted to this particular job, and has since been rendering excellent service "shooting" penstock sections up to 30 feet in diameter.

Schedules have been speeded up, however, so Babcock & Wilcox have ordered two duplicates of their Boulder Dam outfit, one of which goes to Boulder Dam, the other to Barberton. When they are placed in service, Babcock & Wilcox can boast the most entensive x-ray facilities in their field.

You may not have to check 4" welds, but that is only one of the industrial possibilities of the x-ray. If you have a problem of hidden defects, send for the new edition of "Industrial Application of the X-Ray." Address Industrial Department.

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Important Articles in November

General Reviews

25 Years of Progress, Walter Rosenhain, (Paper for British Institute of Metals), Canadian Chemistry & Metallurgy, Oct., p. 210. . . . . Mechanistic Interpretations of Metallurgical Science, L. B. Hunt, Metallurgist, Oct., p. 78. . . . . Place of Metallurgists in Industry, James Aston, (Paper for Society for Promotion of Engineering Education), Iron Age, Nov. 23, p. 21. . . . . Trends in Transportation (Rail) Equipment, Product Engineering, Nov., p. 403.

Reduction of Ores

Lump Peat for Blast Furnace Fuel, B. M. Suslov, Iron Age, Nov. 16, p. 17. . . . . Electric Dust Precipitation — Whessoe Process, Iron & Coal Trades Review, Nov. 10, p. 707. . . . . Blast Furnace Gas Cleaning, Metallurgia, Oct., p. 178.

Fluidity of Iron-Carbon Alloys, René Berger, Metals & Alloys, Nov., p. 176. . . . . The System of Liquid Iron and Carbon Oxides, H. C. Vacher, Bureau of Standards Journal of Research, Oct. p. 541. . . . . Reduction of Manganese Oxide, S. Aoyama, Science Reports, Tohoku University, Oct., p. 824.

Steel Making and Rolling

Making Quality Steels, Emil Gathmann, Blast Furnace & Steel Plant, Nov., p. 590. . . . . Steel Progress, Eric N. Simons, Electrical Review, Oct. 27, p. 585. . . . . Heat Transfer in Open-Hearth, W. C. Buell, (Paper for Iron & Steel Electrical Engineers), Abstract in Steel, Oct. 30, p. 28. . . . . Nozzles & Stopper Rods, H. V. Beasley, Blast Furnace & Steel Plant, Nov., p. 581. . . . . Advances in Electrical Equipment for Steel Making, W. H. Burr, (Paper for Iron and Steel Electrical Engineers), Iron Age, Nov. 16, p. 18.

Heating Slabs for Strip Mills, W. R. Culbertson, (Paper for Iron & Steel Electrical Engineers). . . . . Sheet and Tin Mill Furnaces, R. J. Wean, (Paper for Iron & Steel Electrical Engineers), Abstract in Steel, Oct. 30, p. 28. . . . . Automatic Sheet Catchers, W. B. Snyder, Blast Furnace & Steel Plant, Nov., p. 602. . . . . Roll Breakage in Sheet Mills, W. H. Melaney, Blast Furnace & Steel Plant, Nov., p. 577. . . . . Strip Heating Furnace (Continuous), F. L. Prentiss, Iron Age, Nov. 2, p. 18.

Foundry and Castings

Electric Steel Furnace in Foundry, Steel, Nov. 6, p. 34. . . . . Oil-Fired Rotary Furnaces in England, V. C. Faulkner, Foundry Trade Journal, Oct. 26, p. 231. . . . . European Steel Foundry Practice, Pat Dwyer, Foundry, Nov., p. 22. . . . . Cleaning Castings with High Pressure Water, Foundry, Nov., p. 16. . . . . "Corner Effect" in Castings, J. G. Pearce, Metallurgist, Oct., p. 73.

Research on Cast Iron in England, Engineer, Nov. 10, p. 475. . . . . Transverse Test on Cast Iron, J. T. MacKenzie, Transactions, American Foundrymen's Asso., Oct., p. 7. . . . . Permanent Set in Austenitic Cast Irons, J. E. Hurst, Engineering, Oct. 20, p. 429. . . . . Strength Properties of Cast Iron, J. E. Hurst, Metallurgia, Oct., p. 179.

Alloys in Cast Steel, A Symposium, October Issue, Transactions, American Foundrymen's Asso.; Molybdenum, by H. W. Gillett; Nickel, by A. G. Zima; Vanadium, by J. Strauss; Chromium, by J. H. Critchett; Titanium, by G. F. Comstock.

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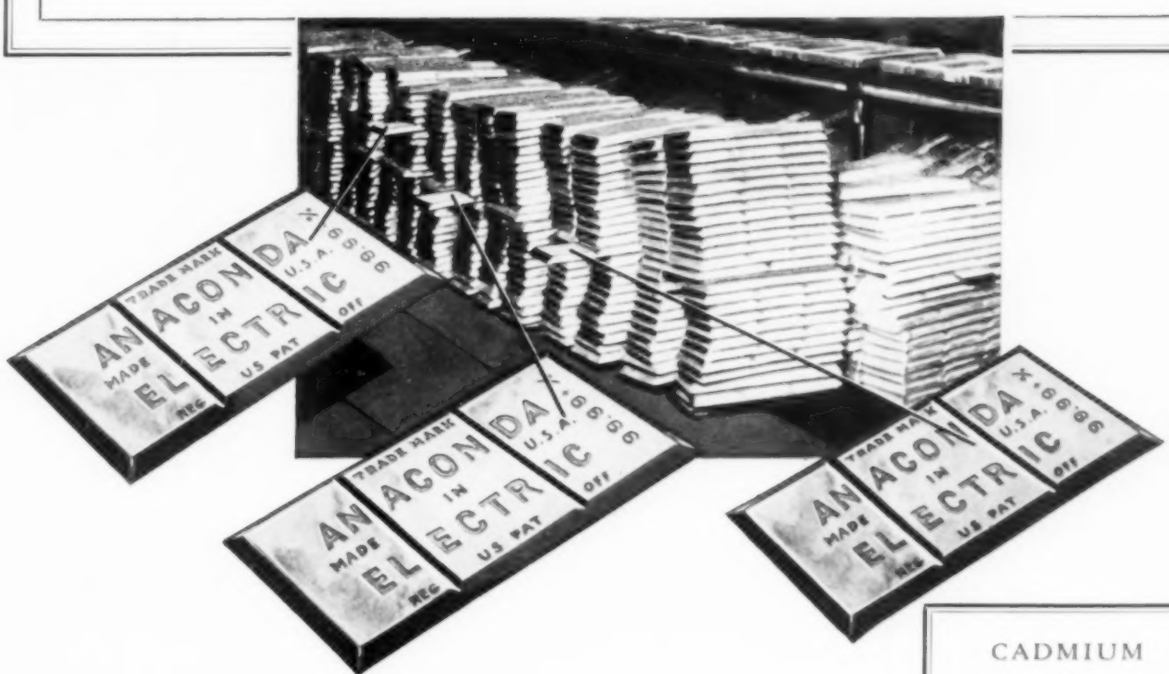

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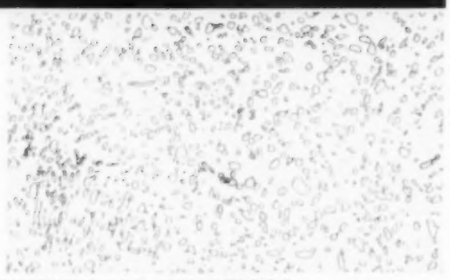
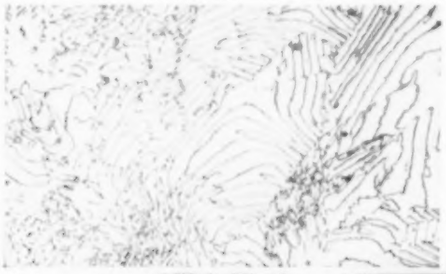
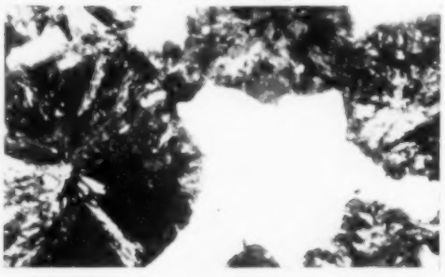


Spheroidal Cementite: Softest and most ductile condition of steel, but not very strong.



Pearlite: Soft and ductile steel. Moderately strong.



Troostite: Hard and strong but only moderately ductile.

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"*Too hard, the stock tears!*" complains the machine shop superintendent. . . . Milling machine cutters, lathe tools, broaches, drills won't hold their edges—and other troubles appear. . . . Look to the annealing for the solution! The structure of metal is fully as important *before* final heat treatment as after, for that is when machinability is determined.

Which of the above photomicrographs represents the metals you are processing now? A metallographic equipment will tell you. Such analyses will cost little enough for the results obtained, will assure you of smooth, well machined parts and can save on your other operations.

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November's Reading

Heat Resisting Cast Irons ("Silal" and "Nicrosilal"), A. L. Norbury, Transactions, American Foundrymen's Asso., Oct., p. 267. . . . . Cast Iron Suitable for Nitrogen Hardening (Nitricastiron and Centrard), J. E. Hurst, Foundry Trade Journal, Nov. 9, p. 259.

60-year Old Highway Bridges of Cast Iron, H. K. Ellis, Engineering News-Record, Nov. 16, p. 597.

Furnaces and Heat Treating

Changes in Fire Brick During Service, J. F. Hyslop, (Paper for Ceramic Society), Metallurgist, Oct., p. 74. . . . . Insulation of Furnaces, Bernard Thomas, Heat Treating & Forging, Oct., p. 49. . . . . New Industrial Furnaces (Heating Furnaces), G. A. Merkt, Paper for Iron & Steel Electrical Engineers.

Heat Transfer from Electric Resistors to Furnaces, E. G. Fiegehen, Engineer, Oct. 20, p. 377. . . . . Electric Annealing of Strip and Sheet, A. N. Otis, (Paper for Iron & Steel Electrical Engineers), Steel, Nov. 13, p. 21 (in part). . . . . Bright Annealing Strip Steel, L. E. Browne, Steel, Oct. 30, p. 25.

Heating and Heat Treating Bolts and Nuts, J. B. Jones, Heat Treating & Forging, Oct., p. 52. . . . . Stress Relieving and Normalizing Welds in Cromansil Steel, A .E. Gibson, Welding, Nov., p. 489.

Properties and Uses of Steel

High Tensile Steel for Boilers, L. C. Ruber, (Report to Master Boiler Makers' Convention), Boiler Maker, Oct., p. 205. . . . . Selection of Steels for Engineering Requirements, Francis W. Rowe, (Paper for Manchester Association of Engineers), Iron and Coal Trades Review, Nov. 3, p. 665.

New Metals for Shipbuilders, F. C. Lea, (Paper for North-East Coast Institution of Engineers and Shipbuilders), Iron & Coal Trades Review, Nov. 10, p. 709. . . . . Effect of 31 Years' Sea Water Immersion on Structural Steel, J. S. Unger, Engineering News-Record, Nov. 16, p. 593. . . . . Steel Sheetpile Jetty, Edgar K. Faster, Engineering News-Record, Oct. 26, p. 489.

Improved Cans for Food Stuffs, Chemical Age, Oct. 28, p. 393.

Influence of Beryllium on Steel (Part 2), J. H. S. Dickenson, (Paper for British Iron & Steel Institute), Iron & Coal Trades Review, Oct. 20, p. 589; also in Foundry Trade Journal, Oct. 26, p. 237. . . . . Iron-Aluminum System, A. Osawa, Science Reports, Tohoku University, Oct., p. 803. . . . . Alloys of Iron and Manganese, F. M. Walters and others, Transactions, A.S.S.T., Nov., p. 1002.

Non-Ferrous

What is an Alloy? Metallurgist, Oct., p. 66. . . . . Figures of Merit for Alloys, W. Rosenhain, Metallurgist, Oct., p. 79.

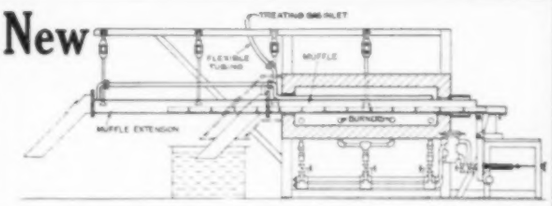
Refining Gold Bullion, Engineering & Mining Journal, Nov., p. 483. . . . . Reduction of Cobalt and Silver, M. Watanabe, Science Reports, Tohoku University, Oct., p. 892. . . . . Molybdenum Concentrator for Morocco, Chemical Age, Nov. 4, p. 27.

Brass Foundry Sanitation, F. G. Steinbach, Foundry, Nov., p. 10. . . . . Manufacture of Non-Ferrous Seamless Tubes, Gilbert Evans, Metallurgia, Oct., p. 167. . . . . Copper Used by Petroleum Industry, L. G. E. Bignell, Oil & Gas Journal, Nov. 9, p. 14. . . . . Treatment of Copper-Lead Scrap, Chemical Age, Nov. 4, p. 28. . . . . Beryllium and Alloys With Copper, Canadian Machinery & Mfg. News, Nov., p. 16.

Hardening of Ni-Cu-Al Alloys, D. G. Jones, (Paper for Institute of Metals), Engineering, Nov. 3, p. 505.

Extrusion of Aluminum and Brass, J. B. Nealey,

New



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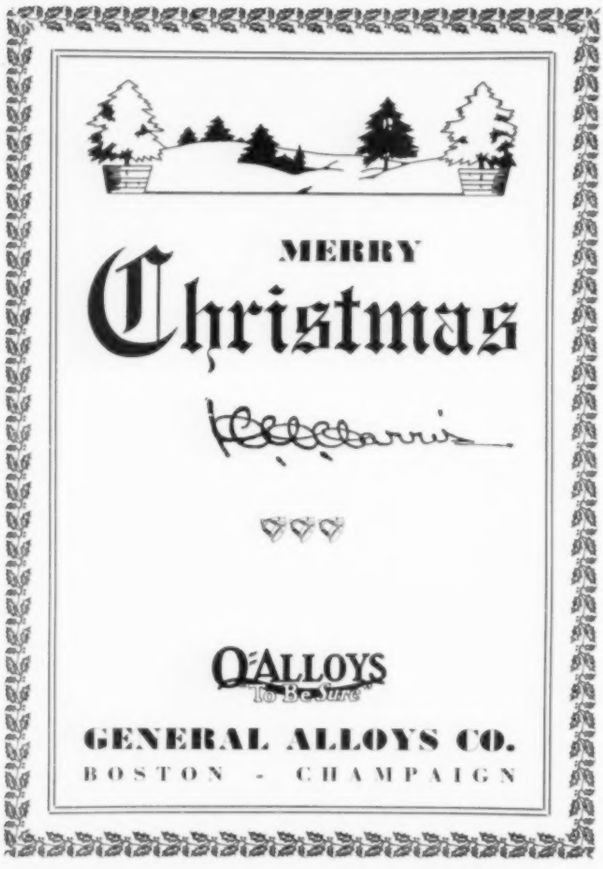

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November's Reading

Machinery, Nov., p. 140. . . . . Carbonate-Chromate Solution for Passivating Aluminum, Gustav Eckert, Chemical Age, Oct. 7, p. 23. . . . . Light Strong Magnesium Alloys, Machine Design, Nov., p. 28.

Die Casting at Doehler Plant, A. H. Allen, Steel, Nov. 20, p. 23.

Heat and Corrosion Resistant Alloys

Additional Elements in Chromium-Iron Castings, W. F. Furman, Metals & Alloys, Nov., p. 167, 174. . . . . Tensile Properties of 25% Chromium, 20% Nickel Rod, John L. Everhart, Wire & Wire Products, Nov., p. 363.

Life of Nickel-Chromium Resistance Alloys, W. Hessenbruch, Metallurgia, Oct., p. 181. . . . . "Inconel" for Corrosion Resistance, R. J. McKay, Metals & Alloys, Nov., p. 177. . . . . Manufacture of Embedded Resistors, Electrical Review, Nov. 3, p. 618.

Stainless Chemical Equipment, C. E. Plummer, Chemical Industries, Nov., p. 407. . . . . Stainless Steel in Machinery for Food Industry, Product Engineering, Nov., p. 411. . . . . Light-Weight Stainless-Steel Passenger Train, Railway Mechanical Engineer, Nov., p. 383. . . . . Metals for Dairy Equipment, Sheet Metal Worker, Nov., p. 359.

Working and Fabrication

Forging Temperatures, J. H. G. Monypenny, Heat Treating & Forging, Oct., p. 38. . . . . Roll-Forge Machine for Concentric Shapes, Steel, Nov. 20, p. 26. . . . . Forgeability of High Speed, O. W. Ellis, Metals & Alloys, Nov., p. 171.

Plastic Forming of Metals (A Series), Erich Siebel, Steel. . . . . Dished Heads for Pressure Vessels, C. O. Sandstrom, Product Engineering, Nov., p. 426. . . . . Matrix (Fusible) Alloys for Die Setting, J. R. Weaver, Machinery, Nov., p. 129.

Forming of Metals for Aircraft, Harold Crary, Metal Stampings, Oct., p. 244.

Effect of Backward Pull Upon the Tension Required to Draw Wire, F. C. Thompson, (Paper for British Iron and Steel Institute), Iron and Coal Trades Review, Oct. 20, p. 599.

Patterns on Sawed Surfaces, T. Hosaka, Science Reports, Tohoku University, Oct., p. 782, (Metal Progress, Oct., p. 54).

Machinability of Normalized Nickel Steel, O. W. McMullan, Transactions, A.S.S.T., Nov., p. 1035.

Welding

Automatic Arc Welding, Engineering, Nov. 3, p. 485. . . . . Welding With Covered Electrodes, E. A. Hurme, (Paper for Iron & Steel Electrical Engineers).

Welding Copper & Copper Alloys, I. T. Hook, (Paper for American Welding Society), American Machinist, Nov. 8, p. 720. . . . . Large Copper Tank Fusion Welded, Welding, Nov., p. 497. . . . . Welding of "Inconel," F. G. Flocke, Welding Engineer, Nov., p. 22. . . . . Hard-Facing in the Dredging Industry, Don Llewellyn, Welding Engineer, Nov., p. 15.

Design of Welded Joints, R. Kraus, Machinery, Nov., p. 150. . . . . Welded Steel Products (Design and Technique), F. L. Lindemuth, (Paper for Iron & Steel Electrical Engineers). . . . . Tests on Electric Welded Drum, E. Ruter, Metallurgist, Oct., p. 77.

Fusion Welding of Boilers and Tenders, H. M. Service, (Report to Master Boiler Makers' Convention), Boiler Maker, Oct., p. 198, 212. . . . . Welding Penstocks for Boulder Dam, Iron Age, Nov. 9, p. 23. . . . . Welding of Metal Houses, Bennett Chapple, (Paper for Iron & Steel Electrical Engineers). . . . . Welded Fac-

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November's Reading

tory Buildings Fabricated on Site, Canadian Machinery & Mfg. News, Nov., p. 31. . . . . Interesting Welded Steel Structures Abroad, F. Faltus, Welding, Nov., p. 492. . . . . Welded Bridge, 1040 ft. Long, R. Leonhardt, Engineering News-Record, Nov. 16, p. 589.

Finishing Operations

Effects of Pickling on Carbon Steel Wire, A. C. Blackall, Wire & Wire Products, Nov., p. 366. . . . . Cleaning Metal Articles, H. R. Simonds, Iron Age, Nov. 23, p. 12. . . . . Metal Cleaners, E. K. Strachen, Metal Cleaning & Finishing, Oct., p. 426.

Setting for Galvanizing Kettle, H. M. Heyn, Steel, Nov. 13, p. 24. . . . . Electro-Galvanizing, H. R. Simonds, Iron Age, Nov. 16, p. 13.

Metals Commonly Used for Electroplating, H. C. Pierce, Western Machinery and Steel World, Nov., p. 328. . . . . Tests of Thickness of Cadmium Coatings, S. G. Clarke, Metal Industry, Nov., p. 373. . . . . Abrasive Resistance of Chromium Plate, R. J. Piersol, Metal Cleaning & Finishing, Oct., p. 411.

Abrasives for Polishing, F. B. Jacobs, Abrasive Industry, Nov., p. 13; Dec., p. 12.

Metal Finishes to Help Sales, H. R. Simonds, Iron Age, Nov. 9, p. 16. . . . . Lacquers for Automobile Finishes, R. C. Martin, Metal Cleaning & Finishing, Oct., p. 415.

Corrosion

Corrosion Fatigue, A. J. Gould, Engineering, Oct. 27, p. 453. . . . . Corrosion and Protection, U. R. Evans, Chemical Age, Nov. 11, p. 433. . . . . Corrosion-Time Relationships of Iron, R. F. Passano, Industrial & Engineering Chemistry, Nov., p. 1247. . . . . Control of Electrolysis of Underground Structures, I. R. Smith, Electric Journal, Nov., p. 450. . . . . Corrosion in Gas Plants, Gas World, Nov. 11, p. 463. . . . . Corrosion of Locomotive Boilers, E. J. Reardon, (Report of Master Boiler Makers' Convention), Boiler Maker, Oct., p. 196.

Scientific Studies and Equipment

Temper Brittleness, Metallurgist, Oct., p. 67. . . . . Deformation of Steel, E. J. Janitzky, Iron Age, Nov. 2, p. 14. . . . . Age Hardening, Metallurgist, Oct., p. 66. . . . . Damping Factor of Cast Iron, W. W. Kerlin, Iron Age, Nov. 16, p. 31. . . . . Mechanism of Crystal Growth, W. P. Davey, Transactions, A.S.S.T., Nov., p. 965.

Preparing Lead Samples for Microscopic Work, B. Jones, (Paper for Institute of Metals), Engineering, Oct. 20, p. 449.

Study of Models to Relieve Fatigue Failures, R. L. Scorah, Machine Design, Nov., p. 31.

Effect of Tin as an Impurity in Mild Steels, J. H. Andrew and J. B. Peile, (Paper for British Iron and Steel Institute), Iron and Coal Trades Review, Oct. 20, p. 596.

Effect of Superheating a Molten Metal, W. L. Webster, (Paper at Royal Society), Metallurgist, Oct., p. 70.

Flange Wear on Steel Wheels, E. J. Jonas, Electric Traction & Bus Journal, Nov., p. 357.

Polishing With Abrasives Carried in Paraffin, R. L. Dowdell, Metals & Alloys, Nov., p. 181.

The Utility of the Spark Test as Applied to Commercial Steels, R. W. Buzzard, Bureau of Standards Journal of Research, Oct., p. 527.

Recording Extensometer, P. Chevenard, Metallurgist, Oct., p. 71. . . . . Bimetal Elements for Thermostats, H. D. Matthews, Product Engineering, Nov., p. 420.

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IN ANY construction where high temperatures are employed the efficient use of heat is an important factor. And with heat-treating furnaces it is especially so because of the severe service to which they are subjected.

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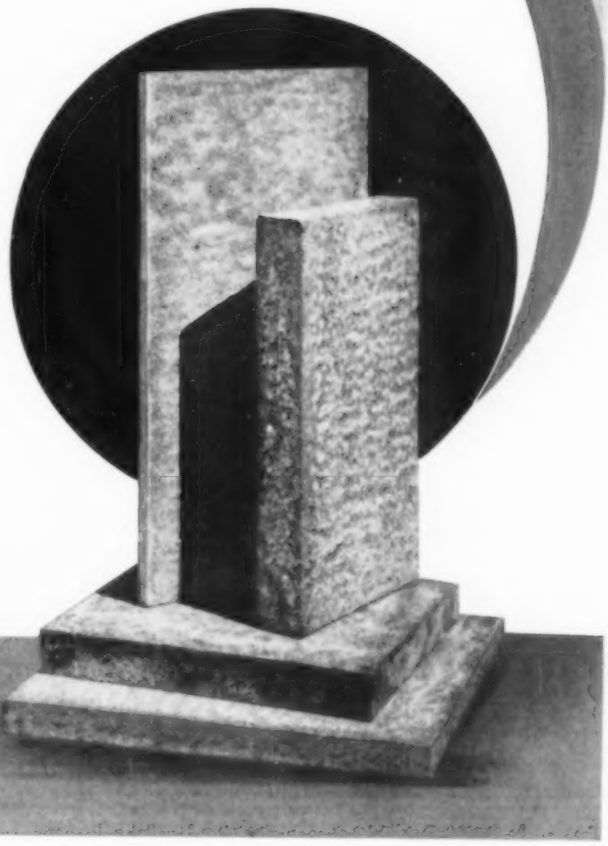

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Atmosphere Furnaces

An interesting folder of Surface Combination Corp. gives performance data on their atmosphere furnaces compiled from installations in actual production. Operations described include bright annealing of ferrous and non-ferrous metals, carburizing, nitriding, forging without scale and hardening without scale. Illustrated. Bulletin De-51.

Properties of Stainless

Ludlum Steel Co. describes the several analyses of Silcrome corrosion and heat resisting steels in a new data sheet. Physical properties are given for each type, as well as a summary of general characteristics. Bulletin De-94.

Nickel Alloy Steels

A recent folder of International Nickel Co., a reprint of a Bureau of Standards publication, explains the effects of adding nickel to steel and emphasizes the physical and mechanical properties of the commonly used nickel steels. Curves and tables illustrate. Bulletin De-45.

Stainless Steel Facts

Designed in convenient file folder format, the new Carpenter Steel Co. booklet, "Working Data and Technical Facts on Stainless Steels", contains a wealth of valuable facts on Carpenter stainless steels. An ingenious system classifies the various analyses into three easily identified types. Bulletin De-12.

To Prevent Rust

The well known rust preventive, No-Ox-Id, is now available from Dearborn Chemical Co. as a foundation for paint. It is available in the colors red, gray or black. A booklet explains how maximum resistance to corrosion can be obtained. Bulletin Ju-36.

Electric Pot Furnace

American Electric Furnace Co. has just published a new 4-page folder showing the construction features and giving the operating advantages of their "American" electric pot furnace as used for lead, salt and cyanide baths. Bulletin Oc-2.

New Foxboro Pyrometer

Foxboro Co. describes the new Foxboro potentiometer recording pyrometer in a recent bulletin. The outstanding features are a new design of balancing mechanism, ability to make from one to six records, a 12-in. chart, rapid recording cycle and a moisture-proof case. Bulletin Au-21.

New Type Furnace

A new bell-type retort furnace made by American Gas Furnace Co. can be used in quick succession for carburizing, nitriding, bright annealing in gas atmospheres, or for hardening, normalizing, tempering or annealing. It is an ideal heat treating tool where production is widely varied in character. Bulletin Jn-11.

Spectrography

The value of spectrographic analysis in manufacturing control is pointed out by Bausch & Lomb Optical Co. in an interesting booklet. This sensitive but rapid instrument is thoroughly explained, emphasis being laid on its practical application in industry. Bulletin Au-35.

New Heat Controller

"Straight Line Control" of furnace temperature is possible with the Trendalizer Controller made by Brown Instrument Co. There is no zig-zagging across the control point, because this unique device changes its control action in accordance with both temperature trend and extent of deviation. Bulletin Sp-3.

Globar Elements

Globar electrical heating units and a variety of accessories for their operation have been catalogued by Globar Corp. A list of the standard industrial type heating elements and a coordinated list of terminal mountings and accessories is included. Bulletin N-25.

High Cr Cast Iron

A pamphlet describing foundry production of cast irons containing from 15 to 30% of chromium has been issued by Electro Metallurgical Co. These cast irons do not grow or scale after repeated heatings and are excellent for high temperature work. Bulletin Ma-16.

Big-End-Up

Gathmann Engineering Co. briefly explains the advantages of steel cast in big-end-up ingots, showing the freedom from pipe, excessive segregation and axial porosity. An 82% ingot-to-bloom yield of sound steel is the usual practice. Bulletin Fe-13.

New Furnace Blowers

Two new types of Turbo-Compressors are described in recent publications of Spencer Turbine Co. Uses for the ⅛ hp. Turbo are presented, as is a description of the new single stage Turbo-Compressor which affords tremendous economies in low pressure gas and oil fired equipment. Bulletin Sp-70.

Scleroscopes

The model D standard recording scleroscope is described and illustrated in a recent publication of Shore Instrument Co. The theory and practice of hardness testing with this portable machine as described in this bulletin reveal a fund of valuable facts. Bulletin S-33.

Cast Vanadium Steel

Jerome Strauss and George L. Norris have written a technical booklet for Vanadium Corp. of America describing the properties developed by steel castings containing various percentages of vanadium. The information given is complete and authoritative. Bulletin S-27.

New Chromium Steel

A new Enduro has just been developed by Republic Steel Corp. — Enduro 4-6% Chromium, which is a fine heat resisting alloy. A new handbook gives full information which will be appreciated by designing and research engineers, metallurgists and metal plant executives. Bulletin No-8.

X-Rays in Industry

General Electric X-Ray Corp. has available a profusely illustrated brochure entitled "Industrial Application of the X-Ray," which gives the complete story of the field of application of this modern inspection tool. Valuable information is presented. Bulletin Ma-6.

New Hardening Method

All three vital factors in correct hardening are completely controlled by the new Vapocarb Hump method of hardening, which is well described in a Leeds & Northrup bulletin. The three factors are: Quench point, rate of heating, and furnace atmosphere. Complete details are given in Bulletin No-46.

Roll Grinding

Carborundum Co. has just published a 50-page booklet on roll grinding which may be considered a handbook of available information on this subject. Carefully written and amply illustrated, this treatise will undoubtedly be of real practical value. Bulletin Au-57.

Stainless Sheets

A very useful booklet describing the stainless steel sheets and light plates made by American Sheet & Tin Plate Co. gives recommendations for fabrication and a description of finishes and analyses available. Bulletin Ap-96.

Bright Annealing

A publication of Electric Furnace Co. describes new developments in controlled atmosphere furnaces for continuous deoxidize annealing, bright normalizing and bright annealing both ferrous and non-ferrous metals. Sheets, strip, coils, tubing and wire come clean, bright and dry from these furnaces. Bulletin No-30.

"Vee-less" Arc Welds

New literature covering a very recent development in arc welding has been prepared by Metal & Thermit Corp. Known as Murex Straight Gap welding, the new process eliminates grooving or "veeing" the edges even of heavy plates. Welding time is halved and other savings are effected, it is claimed. Bulletin My-64.

Quicker Heat Treating

Driver-Harris Co. discusses Nichrome sheet containers for heat treating in an illustrated folder which honestly states that while for certain purposes sheet containers cannot be used economically, there are a multitude of installations where their advantages of lightness and quicker heating can be fully utilized. Bulletin Jl-19.

New Zinc Coating

Wire which has been zinc coated by the new Bethanizing process is described in Bethlehem Steel Co.'s latest folder. This process produces a zinc coating which has proved to be more ductile, tighter, tougher, more uniform and purer. Coatings 3 times as heavy as formerly can be made. Bulletin Au-76.

Maintenance Welding

This interesting booklet describes the use of the oxyacetylene process in the reclamation of broken and worn machine parts, alteration, fabrication and installation of equipment. Such equipment as piping, tanks, machine elements, engine and pump parts and conveying systems is covered in the 16-page illustrated booklet of Linde Air Products Co. Bulletin Jl-63.

Aluminum vs. Corrosion

In the carefully prepared booklet, "Combating Chemical Corrosion with Alcoa Aluminum," published by Aluminum Co. of America, effects of various corrosive agents upon aluminum and its alloys are described in detail. It is an excellent and convenient source of information on this subject. Bulletin Sp-54.

X-Rayed Alloy Castings

A folder just issued by Electro Alloys Co. describes their X-Ray inspection service of Thermalloy heat resisting castings for high temperature work. Considerable data on the use of X-Ray tubes and "radon" capsules to check foundry practice are presented. Typical radiographs and tables of physical properties are included. Bulletin Oc-32.

Optics in Metallurgy

A surprisingly large number of uses for optical instruments in metal working are described in a new booklet of Bausch & Lomb Optical Co. Photomicrography is, of course, prominent among these, but this well illustrated booklet shows many other interesting optical instruments. Bulletin No-35.

Uses of Molybdenum

Climax Molybdenum Co. offers a new and useful 50-page booklet dealing with the benefits conferred by molybdenum as an alloying element in iron and steel. In orderly fashion engineering data are presented and made clear with numerous tables and illustrations. Bulletin Au-4.

Liquid Baths

A competent discussion of liquid baths for heat treating steel at temperatures from 350 to 1800° F. appears in a recent publication of E. F. Houghton & Co. A valuable chapter is devoted to the proper design of furnaces for use with liquid baths which lists 20 general furnace requirements. Bulletin Ja-38.

Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in one of that company's publications. Bulletin D-17.

Electric Furnaces

Full details of the line of electric furnaces made by Hoskins Mfg. Co. are well presented in their latest 42-page catalog. Contents include description and data on 17 types of furnaces and some valuable information on Chromel resistance wires and thermocouples. Bulletin Sp-24.

Cyanide Baths

Much practical information on the heat treatment of steels with cyanides and salts is contained in a descriptive booklet of E. I. duPont de Nemours & Co., R. & H. Chemicals Dept. The booklet contains many valuable suggestions for improved quality heat treating. Bulletin Sp-29.

Quenching Handbook

E. F. Houghton & Co. have published an excellent 80-page handbook on the subject of quenching. More than 30 charts and photomicrographs help tell the story. A copy will be sent free to those who request it. Bulletin Jl-38.

Hardening High Speed

Spoilage is eliminated when high speed steel is hardened in Certain Curtain electric furnaces, claims a new booklet issued by C. I. Hayes, Inc. Grain growth is controlled and the most delicate tools develop maximum hardness without decarburization, scaling or fusing. Bulletin No-15.

Darkfield Microscopy

Comparison is made of darkfield and brightfield metallographic examination in a 16-page publication of E. Leitz, Inc. The equipment necessary for darkfield microscopy is described and prices are given. Several sets of micros of the same field contrast the two methods of illumination. Bulletin Ja-47.

Hardness Testing

Everyone interested in the testing of metals for hardness will do well to have on hand a copy of a catalog recently issued by Wilson Mechanical Instrument Co., illustrating and describing the latest design of Rockwell Hardness Testers and auxiliary work supports. Bulletin Sp-22.

Beryllium-Copper

Beryllium-Copper is a relatively new alloy produced by American Brass Co. which can be heat treated to tensiles as high as 181,000 lb. per sq.in. It is supplied in sheets, wire, rods, tubes and forgings. An excellent booklet gives full information on fabrication and treating. Bulletin No-89.

Pickling Inhibitors

A pamphlet describing the nature and use of Grasselli Inhibitors is available to all those interested in the pickling of steel. It not only describes the merits of these inhibitors, but it gives a table of suggested inhibitor strengths to be used in the pickling of the various grades of steel. Bulletin Ap-95.

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Chromium Plate

(Continued from page 27) a hardness near that of the diamond you would not expect thin plates to stand up under shock nor would you expect them to carry heavy loads when backed up by soft brass. Many failures have been due to these causes. The thin coating cannot show the properties of chromium unless given a fair chance.

Resistance to abrasion is generally thought to be secured from hardness. To a certain extent this is true, but it is also true that "hard" material is usually ground with a relatively soft abrasive. Chromium plate, therefore, does not offer much resistance to the abrasion of sand blown from a blast nozzle. Scour of this sort will be best resisted by special alloys.

Hardness has a marked effect on the design of the article. Many pieces of equipment which failed when chromium plated could have succeeded had sharp edges been eliminated. Cracks and chips start from corners on sharp edges. A rounded edge on a plug gage or on a drying roll is a simple change that can be made without injury to the article and helps obtain success.

Conclusions

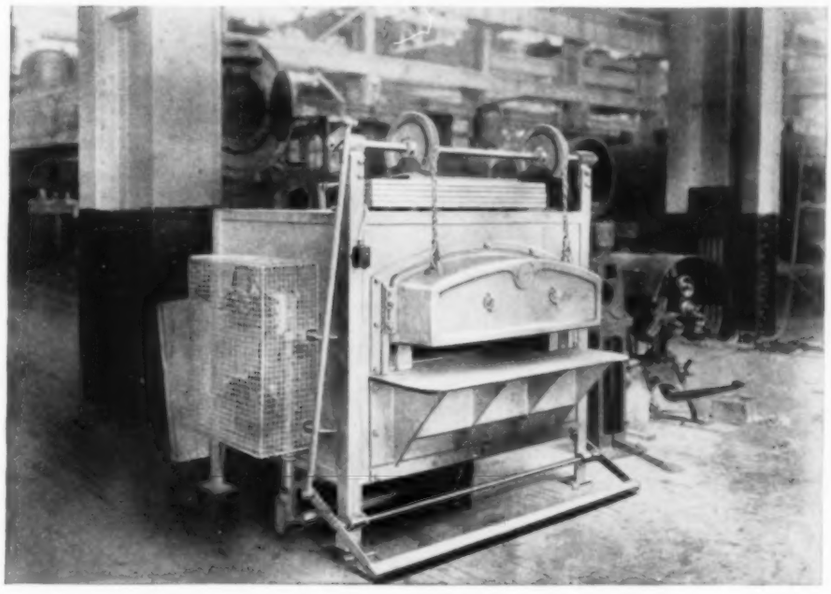
A considerable portion of the failures of chromium plate have been due to faulty applications, which for the most part are caused by ignorance about the possibilities of the metal in very thin layers.

The prospective user should very carefully correlate these properties to his particular problems. He should remember at all times that he is dealing with a thin film or plate and he must therefore make the conditions such that this thin plate will be able to exhibit the true properties of chromium.

Proper selection of the base metal, proper design, and adequate refinishing are essential for wear resistance.

Decorative work is quite different. Corrosion resistance is secured by copper and nickel undercoats, and chromium serves primarily to resist tarnish. Color, hardness, and resistance to atmospheric corrosion are then the essential properties.

"Q. E. D." on Electric Forging—



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But the big difference is in the effect of surface defects. In a leaf spring these defects make little difference; but in a coil spring, because of the nature of the stresses, an extremely fine, hair-line seam, invisible to the naked eye, will give fatigue-producing forces a foothold. Breakage soon results. This is the common reason for the failure of helical springs.

Some years ago Bethlehem metallurgists set out to eliminate this cause of breakage in railway springs. After much study and experiment, a method was developed of making bars free of all surface imperfections. As a result fatigue, the great enemy of helical springs, never has a chance to get in its work.

Are you thinking about independent wheel suspension? Buying your spring-steel bars from Bethlehem will solve one of the important problems involved in the change. *Bethlehem Steel Company, Bethlehem, Pa.*

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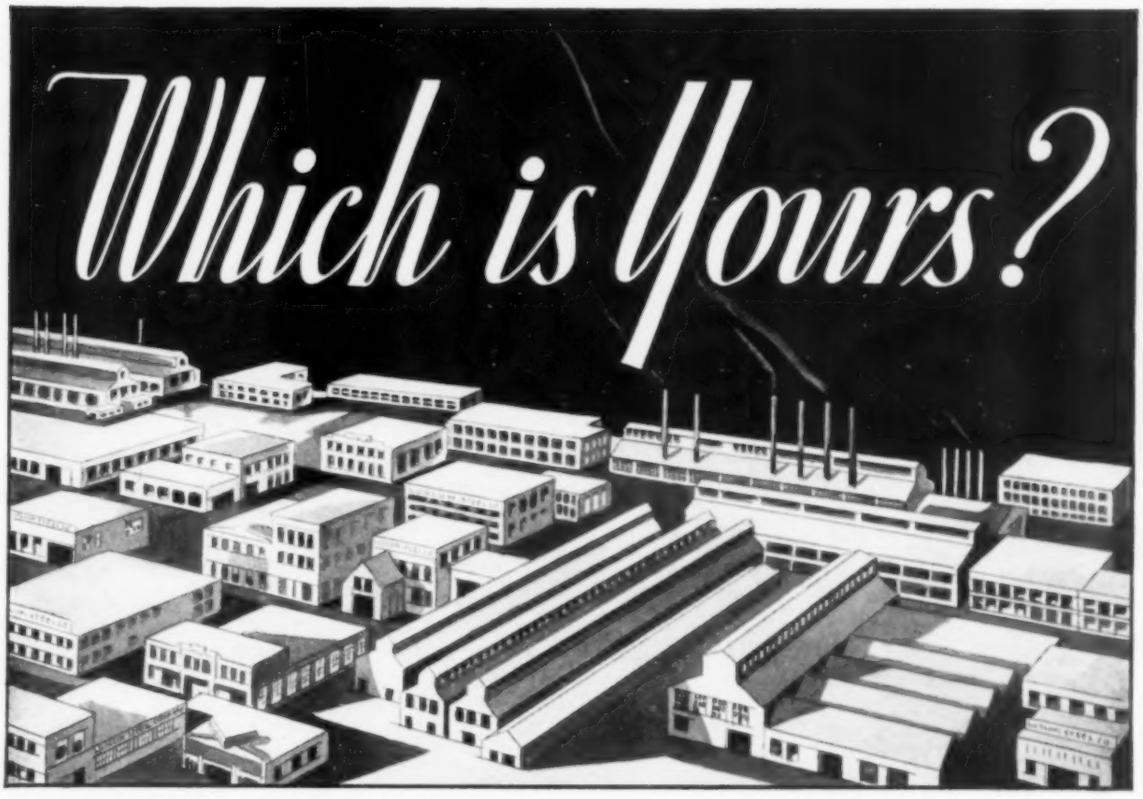

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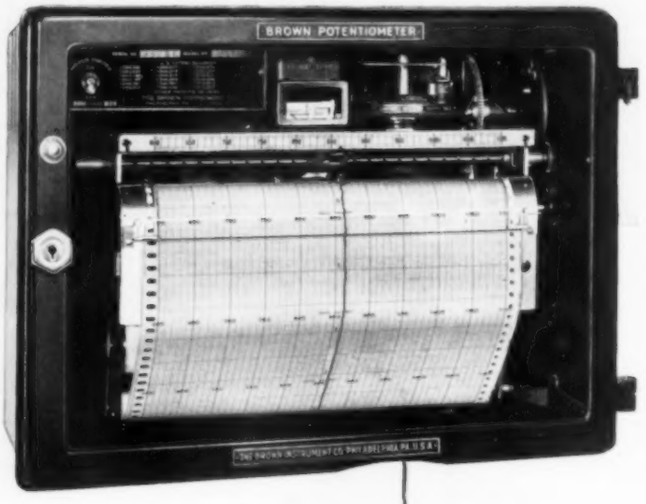

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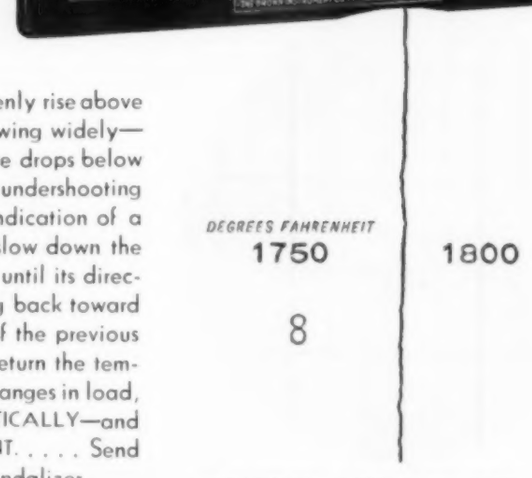

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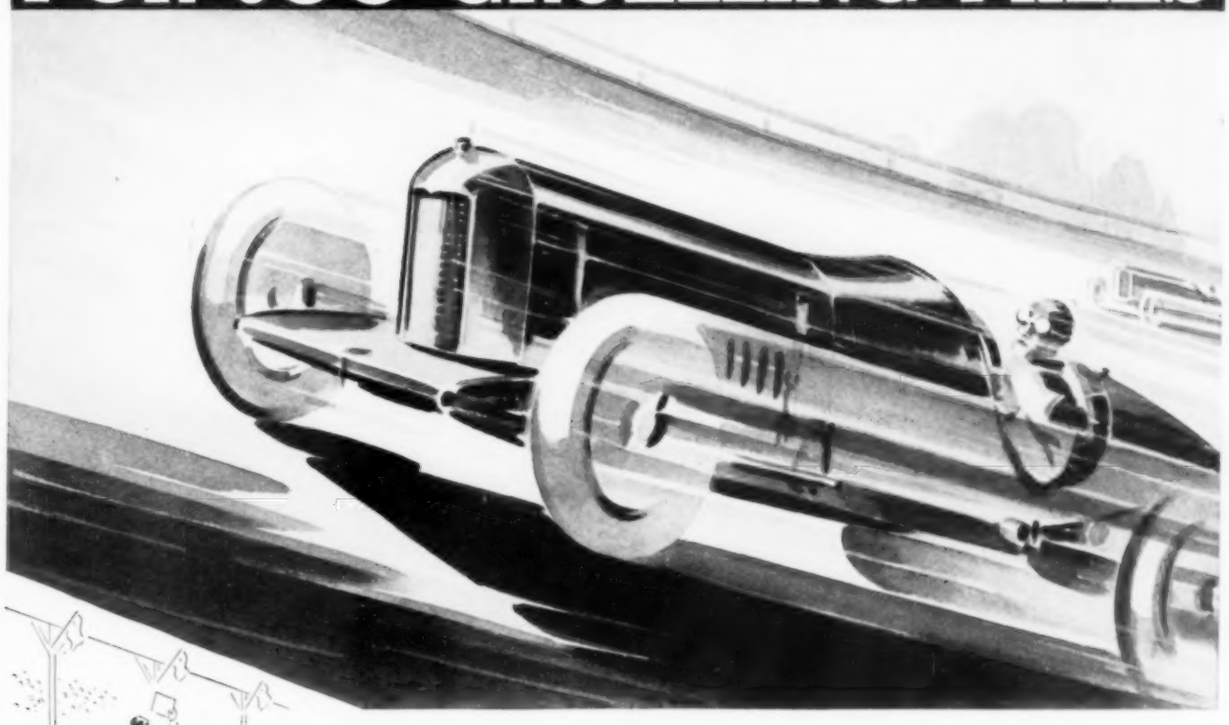

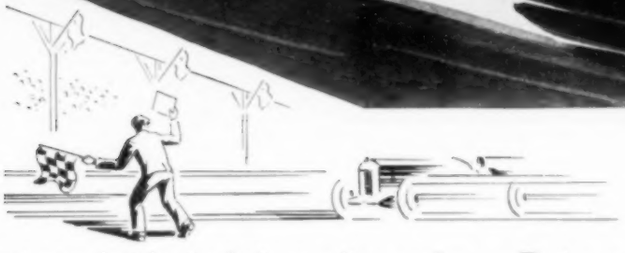

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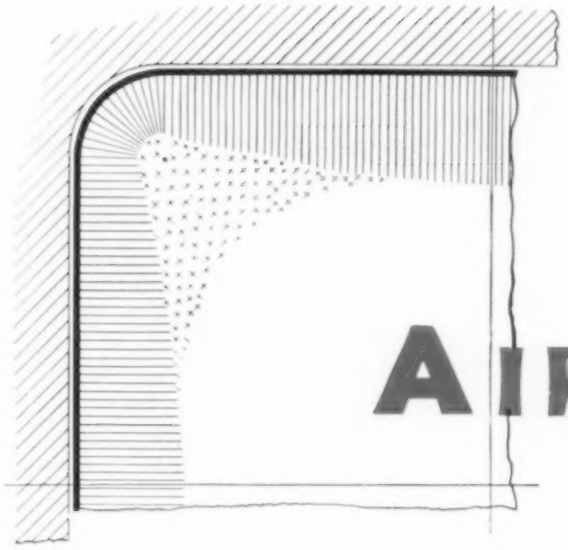
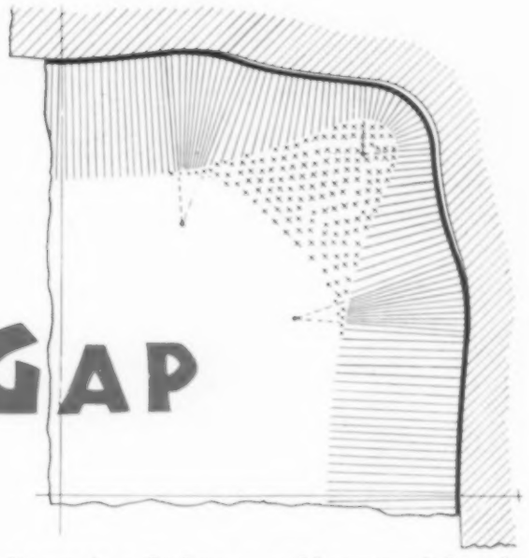


Air gap in a plane-sided contour mold is uniformly wide and solidification-retarding.

AIR GAP



Air gap in a Gathmann mold contour is largely confined to the corner portions, allowing more uniform solidification. Better ingot surface results.

U. S. Patents: July 2, 1929—Jan. 28, 1930
Dec. 27, 1932—June 13, 1933

ONE of the most ignored factors in ingot solidification is the air gap that is formed between mold and ingot soon after the initial ingot skin is formed. This gap is caused by the expansion of the mold and the contraction of the ingot.

Up to the time of forming of the air gap, cooling and solidification of the ingot mass progresses rapidly thru conduction of heat by the mold walls. On formation of the air gap, however, cooling is retarded and solidification continues slowly, primarily by radiation thru the inert air surrounding the ingot.

In modern Gathmann ingot molds, this factor of insulation by air gap is recognized and controlled by scientific design of the mold chamber walls. Suitable corrugations in the ingot-forming chamber and relatively small primary corners, combine to maintain contact of the ingot with the mold at the primary sides for a considerable period after the air gap has formed at the corner portion. These features allow cooling of the ingot mass to progress more rapidly and uniformly than in any other type of cross section. A more homogeneous ingot with improved surface results; and in both rimming and killed heats, the condition of the surface of your product is of paramount importance.

Improving the quality of ingots by scientific mold design is our business. We would appreciate an opportunity to discuss Gathmann ingot contours with you.

THE GATHMANN ENGINEERING CO.

"Designers of Ingot Molds Since 1909"

BALTIMORE, MARYLAND

New Developments

We have made the following recent developments and installations:

New Continuous Bright Annealing Furnaces for ferrous and non-ferrous metals. Sheet, strip, tubing, stampings, finished and semi-finished parts are delivered bright and dry.

New Continuous Brazing Furnaces. The most intricate assemblies are joined and delivered continuously.

Strip Annealing Furnaces. A new fuel-fired removable hood type furnace anneals strip in coils - - - shows lower fuel and maintenance cost, shorter annealing time, more uniform results, greater flexibility and ease of operation.

Wire Annealing Furnaces. An improved pit type furnace anneals wire in coils. Has the following advantages: Increased tonnage per pit; improved fuel economy; more uniform anneal; improved surface condition, decreased annealing time and labor requirements.

Bright Annealing Copper Wire. A new continuous furnace anneals fine copper wire on spools - - - bright and dry.

Our Engineering Department will be glad to consult with you on your heating or heat-treating problems.

THE ELECTRIC FURNACE CO.

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